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U. S. DEPARTMENT OF AGRICULTURE,

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NUTRITION INVESTIGATIONS

AT THE

UNIVERSITY OF TENNESSEE

IN

1896 and 1897.

BY

CHAS. E. WAIT, Ph. D., F. C. S.,
PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF TENNESSEE.

WASHINGTON:
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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 6, 1898.

Sir: I have the honor to transmit herewith a report on nutrition investigations at the University of Tennessee in 1896–97. The investigations were carried on by Prof. Chas. E. Wait, under the immediate supervision of Prof. W. O. Atwater, special agent in charge of nutrition investigations, in accordance with instructions given by the Director of this Office.

The investigation includes studies of the composition of a side of beef, a side of mutton, and of the flesh of chickens; two dietary studies with mechanics' families and two with students' clubs; and a number of experiments with man on the digestibility of combinations of two food materials and of a mixed diet. In connection with these latter experiments the balance of income and outgo of nitrogen was usually determined also.

The University of Tennessee possesses well-equipped laboratories, which were available for the purposes of the investigation. In the prosecution of the work Professor Wait had the assistance and cooperation of Messrs. C. O. Hill, J. O. La Bach, and C. A. Mooers, all of the university. The editorial work in connection with the final preparation of the report for publication was very largely done by Mr. A. P. Bryant, at Middletown, Conn.

This report is respectfully submitted with the recommendation that it be published as Bulletin No. 53 of this Office.

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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NUTRITION INVESTIGATIONS AT THE UNIVERSITY OF TENNESSEE IN 1896 AND 1897.

INTRODUCTION.

The investigations described in this report are (1) studies of the composition of different kinds of meat, including analyses of a side of native Tennessee beef divided into seventeen cuts according to the usages of the Knoxville market, of a side of native Tennessee mutton divided into six cuts, and of twenty Tennessee chickens as purchased in the open market; (2) dietary studies including two mechanics' families living in Knoxville and two college clubs; and (3) twenty-one digestion experiments with healthy men.

Methods followed.—These investigations are quite similar in many respects to those carried on during the year 1895.[1] The methods of analysis used were those of the Association of Official Agricultural Chemists, with such modifications as have been suggested by Atwater and Woods.[2]

All fuel values, unless otherwise stated, are calculated by the use of Rübner's commonly accepted factors (see p. 7). In the digestion experiments the actual heats of combustion were determined by the bomb calorimeter.

COMPOSITION OF DIFFERENT KINDS OF MEAT.

COMPOSITION OF A SIDE OF BEEF.

Between thirty and forty samples of native Tennessee beef were analyzed in connection with dietary studies previously reported.[3] These showed a considerably smaller amount of fat than is contained in similar cuts of Western beef as sold there and in the Eastern markets.[4] For this reason it seemed desirable to determine the percentage composition of a complete side of native Tennessee beef of medium size and fatness. A side of beef slaughtered for the Knoxville market was selected for this purpose and was cut up according to local usages. It was divided into seventeen cuts, of which eight belonged to the fore quarter and nine to the hind quarter, as shown in the accompanying diagrams (fig. 1).

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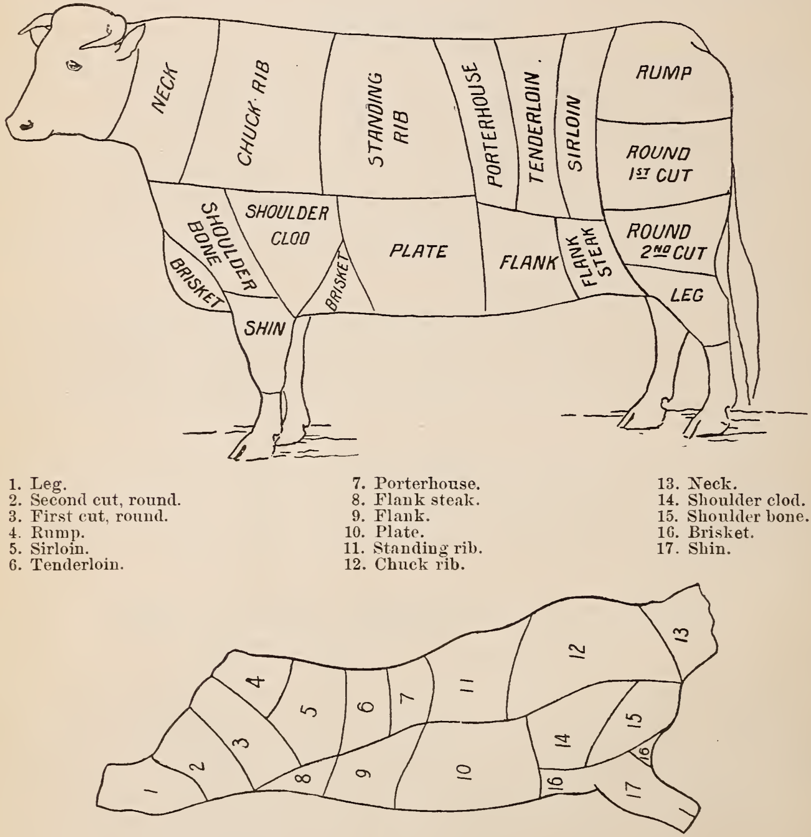
[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 29. (For a list of food and nutrition publications of the Office of Experiment Stations see cover.)

[2] Connecticut Storrs Sta. Rpt. 1891, p. 47.

[3] U. S. Dept. Agr., Office of Experiment Stations Bul. 29.

[4] U. S. Dept. Agr., Office of Experiment Stations Bul. 28.

A representative portion of several pounds weight was selected from each cut. The edible material was separated from the refuse (bone, gristle, etc.) and each carefully weighed, after which the edible portion was passed through a meat cutter. Samples were prepared for analysis in the usual manner. The samples were analyzed by the ordinary methods with the modifications noted beyond. The protein was estimated by multiplying the nitrogen by 6.25. In the analyses previously reported[1] the protein was estimated by difference. Neither method for the estimation of protein is as accurate as could be desired. Estimating protein as nitrogen multiplied by 6.25 has the advantage that it accords with the common usage in the analyses of vegetable materials, and also with the method followed in digestion and metabolism experiments. Sufficient data are here given for either method of calculation.



1. Leg.
2. Second cut, round.
3. First cut, round.
4. Rump.
5. Sirloin.
6. Tenderloin.
7. Porterhouse.
8. Flank steak.
9. Flank.
10. Plate.
11. Standing rib.
12. Chuck rib.
13. Neck.
14. Shoulder clod.
15. Shoulder bone.
16. Brisket.
17. Shin.

FIG. 1.—Diagrams of cuts of beef (Knoxville market).

The actual weight of the water, protein, fat, and ash in any cut is obtained by multiplying the total weight of the cut by its percentage composition. From the total weight of the cuts in the fore quarter, together with the total amount of protein, fat, etc., contained in these cuts, the percentage composition of the fore quarter is obtained. In a like manner the composition of the hind quarter and whole side is computed.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 29.

The available fuel values[1] per pound are calculated by use of the commonly accepted factors proposed by Rübner, which assign 4.1 calories to each gram of protein (and carbohydrates) and 9.3 calories to each gram of fat. These values are equivalent to 18.6 calories for each hundredth of a pound of protein (and carbohydrates) and to 42.2 calories for each hundredth of a pound of fat.

The results of the analyses are shown in the tables below. Table 1 shows the total weights of the different cuts, the weights of the edible portion and refuse, and the percentage composition of the material "as purchased," including both edible portion and refuse. Table 2 shows the composition of the edible portion and of the water-free substance.

TABLE 1.—*Weights of cuts and percentage composition of a side of Tennessee beef of medium fatness as found in the markets.*

3

Portion taken for analysis.	Reference number.	Weights.			Percentage composition.					
		Total cut.	Edible portion.	Refuse (bone, skin, etc.).	Refuse (bone, skin, etc.).	Water.	Protein (N × 6.25).	Fat.	Ash.	Fuel value of 1 pound.
		Lbs.	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Neck	143	13.0	10.1	2.9	22.3	57.4	16.2	3.1	0.8	430
Chuck ribs	31	30.0	23.4	6.6	22.0	55.9	15.3	5.9	.8	535
Standing ribs	195	17.5	13.8	3.7	20.9	45.2	13.9	19.3	.7	1,075
Shoulder bone	358	6.5	3.0	3.5	53.4	34.3	9.2	2.6	.4	280
Shoulder clod	338	15.0	14.2	.8	5.6	69.4	18.5	4.7	1.0	555
Brisket	3	3.5	2.4	1.1	25.0	44.7	12.8	16.9	.6	950
Do	4	4.5	3.4	1.1	30.4	39.5	11.5	18.1	.6	975
Shin	308	6.2	3.1	3.1	50.4	36.5	10.5	2.0	.5	280
Plate	167	4.6	3.5	1.1	24.2	45.4	12.3	17.6	.6	970
Total fore quarter	364	100.8	76.9	23.9	23.7	52.1	14.6	8.7	.7	645
Porterhouse	95	16.0	13.5	2.5	15.6	49.5	15.0	18.8	.7	1,080
Tenderloin	93	11.0	9.0	2.0	18.0	47.8	14.5	19.1	.8	1,070
Sirloin	94	8.0	7.9	.1	8.3	58.1	16.6	17.0	.9	980
Rump	299	8.2	6.3	1.9	22.9	40.4	11.0	23.0	.7	1,210
Round, first cut	258	24.0	22.7	1.3	5.5	67.4	19.6	6.3	.9	635
Round, second cut	280	14.0	13.0	1.0	6.9	65.2	18.7	8.0	.9	690
Flank	46	4.8	3.1	1.7	35.8	39.8	11.9	12.2	.6	735
Flank steak	41	1.2	1.2	....	....	70.8	20.3	7.8	1.0	710
Leg	325	8.2	2.6	5.6	68.3	22.8	6.7	1.9	.3	205
Total hind quarter	374	95.4	79.3	16.1	16.8	53.8	16.0	12.4	.8	825
Whole side, without tallow and kidney	392	196.2	156.2	40.0	20.4	52.9	15.3	10.5	.8	730

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[1] Not all the energy contained in a food material is available for use in the body, because more or less escapes oxidation. Of the unoxidized or partially oxidized products the larger portion is excreted by the intestines. A smaller portion is excreted by the kidneys in the urea and allied organic substances. The unoxidized compounds of the urine come from material which has been digested. They consist mainly of residues of protein compounds, urea, creatinin, etc. Of the potential energy of the digested protein only about three-fourths becomes available in the body by cleavage and oxidation. The rest escapes in the nitrogenous compounds of the urine.

TABLE 2.—*Composition of edible portion and of water-free substance of side of Tennessee beef.*

Portion taken for analysis.	Reference number.	In edible portion.					In water-free substance.		
		Water.	Protein (N×6 25).	Fat.	Ash.	Fuel value of 1 pound.	Protein (N×6.25).	Fat.	Ash
		Per ct.	*Per cent.*	*Per ct.*	*Per ct.*	*Calories.*	*Per cent.*	*Per ct.*	*Per ct.*
Neck	143	74.0	20.9	4.1	1.1	560	80.6	15.7	4.2
Chuck ribs	31	71.6	19.6	7.5	1.1	685	68.9	26.6	3.7
Standing ribs	195	57.1	17.6	24.4	.9	1,355	41.1	56.9	2.0
Shoulder bone	358	73.5	19.8	5.6	1.0	605	74.7	21.2	3.9
Shoulder clod	338	74.5	19.6	4.8	1.0	570	76.8	18.8	4.1
Brisket	3	59.6	17.0	22.5	.9	1,265	42.2	55 8	2.1
Do	4	56.8	16.5	25.9	.9	1,400	38.2	60.1	2.0
Shin	308	73.5	21.2	4.0	1.0	570	80.2	15.2	3.8
Plate	167	59.9	16.2	23.2	.8	1,280	40.4	57.9	2.0
Total fore quarter	364	68.3	19.1	11.4	.9	840	60.3	36.0	2.8
Porterhouse	95	58.6	17.8	22.3	.9	1,280	43.1	53.8	2.1
Tenderloin	93	58.3	17.7	23.3	.9	1,310	42.5	55.8	2.2
Sirloin	94	63.4	18.1	17.1	.9	1,065	49.4	46.8	2.6
Rump	299	52.4	18.5	29.9	.9	1,575	35.3	62.8	1.8
Round, first cut	258	71.3	20.7	6.7	1.0	675	72.3	23.3	3.7
Round, second cut	280	70.0	20.1	8.6	1.0	740	66.9	28.6	3.4
Flank	46	62.0	18.5	19.0	.9	1,140	48.6	50.0	2.3
Flank steak	41	70.8	20.3	7.8	1.0	710	69.8	26.7	3.6
Leg	325	71.9	21.0	5.8	1.1	640	74.7	20.7	3.9
Total hind quarter	374	64.6	19.2	14.9	1.0	990	54.2	42.1	2.8
Whole side, without tallow and kidney	392	66.5	19.2	13.2	1.0	915	57.3	39.4	3.0

In the following table the percentage composition of the side of native Tennessee beef is compared with the average composition of beef raised in other localities:

TABLE 3.—*Composition of edible portion of a side of Tennessee beef compared with that of beef grown elsewhere.*

Source of beef.	Water.	Protein (N×6.25).	Fat.	Ash.	Fuel value per pound.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Fore quarter:					
Tennessee	68.3	19.1	11.4	0.9	840
Texas (average 3 analyses)[1]	70.3	19.7	10.2	.8	975
Colorado (average 3 analyses)[1]	63.2	18.5	18.2	.9	1,110
Maine (average 4 analyses)[2]	60.7	[3]17.0	21.5	.8	1,225
Illinois[4] (average 6 analyses)[1]	56.2	18.1	26.2	.8	1,440
Hind quarter:					
Tennessee	64.6	19.2	14.9	1.0	985
Texas (average 3 analyses)[1]	67.7	20.6	11.8	1.0	881
Colorado (average 3 analyses)[1]	63.7	19.2	17.0	1.0	1,075
Maine (average 4 analyses)[2]	59.1	[3]17.3	22.8	.8	1,285
Illinois[4] (average 6 analyses)[1]	58.8	18.9	22.5	.9	1,300
Side:					
Tennessee	66.5	19.2	13.2	1.0	915
Texas (average 3 analyses)[1]	69.0	20.1	11.0	.9	840
Colorado (average 3 analyses)[1]	63.4	18.9	17.7	.9	1,100
Maine[4] (average 6 analyses)[2]	59.9	[3]17.1	22.2	.8	1,255
Illinois[4] (average 6 analyses)[1]	57.1	18.5	24.9	.8	1 395

[1] Analyzed by Atwater and Woods, Connecticut (Storrs) Agricultural Experiment Station.
[2] Analyzed by W. H. Jordan, Maine Agricultural Experiment Station.
[3] Protein by difference; protein by factor not given.
[4] And neighboring States.

It will be seen from this table that the Texas range beef is the leanest, though differing but little from Tennessee beef in this respect. The Colorado range beef comes third, followed by that raised in New

England. The beef from the grain-producing States, Illinois and the neighboring region, is by far the fattest, containing nearly two and one-half times the amount found in the Tennessee beef. It will also be noticed that in general the larger the amount of fat the less the amounts of protein and water (see p. 8). The protein content of the side here analyzed is slightly larger than that of the other sides with which it is compared, with the exception of the Texas beef.

As far as protein is concerned, the sides of Tennessee beef, which were believed to be representative, seem to be superior to the average Western meat, but as regards the energy they fall considerably below the latter. The number of sides analyzed is, however, hardly sufficient for detailed and definite conclusions.

COMPOSITION OF A SIDE OF MUTTON.

From the preceding data it appears that ordinary Western beef is fatter than that raised in Tennessee. For the purpose of learning whether this was true as regards other kinds of meat, a side of mutton (believed to be representative), which was raised in this State and slaughtered in Knoxville, was purchased and analyzed. This side was divided into cuts according to the custom of the Knoxville market, which is the same as that of other markets.[1] The cuts are shown in the accompanying diagram (fig. 2).

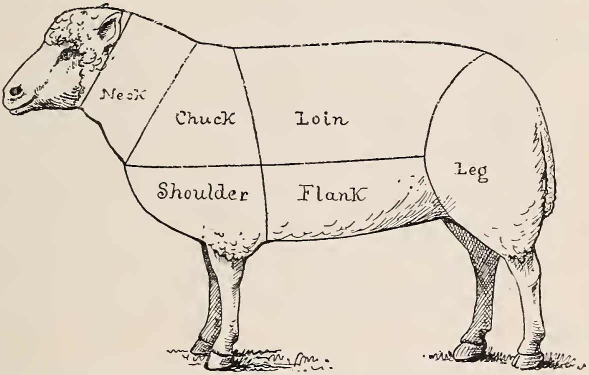

FIG. 2.—Diagram of cuts of mutton.

The statement on page 6 explaining the tables on the composition of beef apply here also. The side was divided into fore quarter and hind quarter, though strictly speaking the loin and flank include a portion of the fore quarter corresponding to the standing ribs and plate of the fore quarter of beef.

The samples were prepared for analysis as described above. The results of the analyses are given in the following tables.

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[1] See U. S. Dept. Agr., Farmers' Bul. 34, and Yearbook, 1895, p. 572.

TABLE 4.—*Weights of cuts and composition of side of Tennessee mutton of medium fatness as found in the markets.*

Portion taken for analysis.	Reference number.	Weights.				Percentage composition.				
		Total cut.	Edible portion.	Refuse (bone, skin, etc.).	Refuse (bone, skin, etc.).	Water.	Protein (N × 6.25).	Fat.	Ash.	Fuel value of 1 pound.
		Lbs.	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Neck	1581	1.1	0.9	0.2	18.7	46.6	13.1	20.7	0.7	1,120
Chuck	1520	2.9	2.3	.6	19.5	52.1	14.3	13.1	.8	825
Shoulder	1590	2.1	1.8	.6	27.2	45.0	12.6	14.6	.7	850
Total fore quarter	1602	6.4	5.0	1.4	22.2	50.0	13.4	13.3	.8	815
Loin	1567	4.6	3.5	1.1	23.8	39.2	11.8	24.9	.6	1,265
Leg	1553	6.1	4.7	1.4	22.7	48.7	13.9	13.8	.8	835
Flank	1537	2.1	1.7	.4	17.7	40.2	12.2	29.6	.7	1,465
Total hind quarter	1612	12.8	9.9	2.9	22.4	43.1	12.9	20.5	.6	1,115
Whole side, not including tallow and kidney	1647	19.2	14.9	4.3	22.3	45.4	13.1	18.1	.7	1,015

TABLE 5.—*Composition of edible portion and of water-free substance of side of Tennessee mutton.*

Portion taken for analysis.	Reference number.	In edible portion.					In water-free substance.		
		Water.	Protein (N×6.25).	Fat.	Ash.	Fuel value of 1 pound.	Protein (N×6.25).	Fat.	Ash.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*	*Per ct.*	*Per ct.*	*Per ct.*
Neck	1581	57.3	16.1	25.4	0.9	1,375	37.8	59.5	2.1
Chuck	1520	64.7	17.8	16.3	1.0	1,020	50.4	46.1	2.7
Shoulder	1590	61.8	17.3	20.1	.9	1,165	45.3	52.6	2.4
Total fore quarter	1602	64.3	17.2	17.1	1.0	1,050	48.2	47.9	2.8
Loin	1567	51.5	15.5	32.7	.8	1,660	31.3	67.4	1.7
Leg	1553	63.0	18.0	17.9	1.0	1,090	48.7	48.4	2.6
Flank	1537	48.9	14.8	35.9	.8	1,785	28.9	70.3	1.6
Total hind quarter	1612	55.5	16.7	26.4	.8	1,435	37.5	59.3	1.8
Whole side, not including tallow and kidney	1647	56.4	16.8	23.3	.9	1,310	38.5	56.0	2.2

The following table gives a comparison of the composition of the side of mutton here analyzed with the available analyses of similar sides from other localities.

TABLE 6.—*Comparison of Tennessee mutton with that from other localities.*

Source of mutton.	Water.	Protein (N×6.25).	Fat.	Ash.	Fuel value per pound.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Fore quarter:					
Tennessee	64.3	17.2	17.1	1.0	1,040
Eastern[1] (1 analysis)	52.2	16.8	29.9	.9	1,575
Western[1] (average 8 analyses)	51.6	15.6	32.7	.9	1,670
Hind quarter:					
Tennessee	55.5	16.7	26.4	.8	1,425
Eastern[1] (1 analysis)	54.7	16.7	27.5	.9	1,470
Western[1] (average 8 analyses)	54.8	17.1	28.3	.8	1,510
Side:					
Tennessee	58.4	16.8	23.3	.9	1,295
Eastern[1] (1 analysis)	53.5	16.8	28.7	.9	1,525
Western[1] (average 8 analyses)	53.1	16.4	30.7	.8	1,600

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[1] Analyzed by Atwater and Woods, Connecticut (Storrs) Agricultural Experiment Station.

The above figures indicate that, as in the case of beef, this side of Tennessee mutton, which was believed to be representative, was leaner than the average Western mutton.

It will be seen that there is a considerable difference between the fat content of the fore quarter of the Tennessee and the Western mutton. The difference in the hind quarter is scarcely noticeable, so that, taking the side as a whole, there is much less variation than was found in the case of beef.

COMPOSITION OF THE FLESH OF CHICKEN.

The low cost of raising chickens and the price at which they are sold in the Southern States, in addition to their nutritive value, make them an important article of food. Comparatively few analyses of Southern-grown chickens have been reported. Since chickens are such a common article of diet in large sections of the country, it was believed that a more extended study of their food value was desirable.

Twenty chickens of average size and fatness were purchased in the open market in Knoxville, at a cost of 25 cents each. They weighed, dressed, on an average 2.25 pounds, without the giblets—i. e., gizzard, heart, and liver. The chickens were prepared for analysis and samples taken as described on page 6.

In the following tables the results of the analyses are shown:

TABLE 7.—*Composition of Tennessee chickens of medium fatness as found in the market.*

	Reference number.	Weights.			Percentage composition.					
		Total.	Edible portion.	Refuse (skin, bone, etc.).	Refuse.	Water.	Protein (N×6.25)	Fat.	Ash.	Fuel value of 1 pound.
		Lbs.	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Chicken, without gizzard, heart, and liver	2709	1.91	1.32	0.59	30.8	45.8	14.4	8.7	0.8	625
Do	2710	2.10	1.59	.51	24.3	50.0	13.8	11.7	.6	745
Do	2711	1.83	1.35	.48	26.1	46.7	11.4	15.7	.5	865
Do	2712	2.49	1.86	.63	25.1	50.5	15.1	8.9	.8	650
Do	2713	2.57	1.96	.61	23.9	43.1	13.8	20.0	.7	1,075
Do	2714	2.49	1.87	.62	24.9	47.5	14.6	12.8	.7	800
Do	2715	2.48	1.89	.59	23.8	41.3	13.3	21.5	.6	1,145
Do	2716	2.16	1.69	.47	21.9	48.0	13.8	15.6	.8	915
Do	2717	1.83	1.31	.52	28.7	50.4	13.8	6.9	.6	540
Do	2718	2.47	1.87	.60	24.3	50.6	14.3	10.6	.6	705
Do	2719	2.85	2.12	.73	25.5	48.9	13.2	11.7	.6	740
Do	2720	2.87	2.29	.58	20.1	46.8	14.8	17.9	.7	1,025
Do	2721	1.98	1.51	.47	23.6	50.5	16.0	9.5	.8	690
Do	2722	1.90	1.35	.55	29.1	46.4	15.5	8.4	.7	640
Do	2723	2.15	1.59	.56	25.9	42.9	15.3	14.9	.7	920
Do	2724	2.24	1.73	.51	23.0	48.9	15.9	11.5	.8	705
Do	2725	1.76	1.32	.44	25.0	45.3	15.5	13.3	.7	850
Do	2726	2.03	1.53	.50	24.4	49.3	15.0	10.7	.7	730
Do	2727	1.92	1.42	.50	26.1	46.0	13.0	14.2	.7	840
Do	2728	2.41	1.88	.53	21.9	51.5	14.4	11.5	.7	750
Average		2.22	1.67	.55	24.9	47.5	14.3	12.8	.7	800

TABLE 8.—*Composition of edible portion and of water-free substance of Tennessee chickens.*

	In edible portion.						In water-free substance.		
	Reference number.	Water.	Protein (N×6.25).	Fat.	Ash.	Fuel value of 1 pound.	Protein (N×6.25).	Fat.	Ash.
Chicken, without gizzard, heart, and		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*	*Per ct.*	*Per ct.*	*Per ct.*
liver	2709	66.2	20.8	12.6	1.1	905	61.7	37.3	3.2
Do	2710	66.0	18.2	15.5	.8	980	53.6	45.7	2.3
Do	2711	63.3	15.4	21.2	.7	1.170	42.1	57.8	1.9
Do	2712	67.4	20.2	11.9	1.0	870	62.1	36.6	3.1
Do	2713	56.7	18.1	26.3	.9	1.410	41.8	60.7	2.0
Do	2714	63.3	19.5	17.0	.9	1,065	53.1	46.2	2.5
Do	2715	54.1	17.5	28.3	.8	1,505	38.1	61.6	1.8
Do	2716	61.5	17.7	19.9	1.0	1.170	46.1	51.8	2.5
Do	2717	70.7	19.3	9.7	.8	760	66.0	33.1	2.7
Do	2718	66.8	18.9	14.0	.8	930	56.8	42.1	2.3
Do	2719	65.6	17.7	15.7	.8	995	51.6	45.7	2.3
Do	2720	58.6	18.5	22.4	.9	1.280	44.8	54.0	2.2
Do	2721	66.1	21.0	12.5	1.0	905	61.9	36.8	3.0
Do	2722	65.4	21.8	11.9	1.1	905	63.1	34.5	3.0
Do	2723	57.8	20.7	20.1	1.0	1,240	49.0	47.6	2.3
Do	2724	63.5	20.7	14.9	1.0	1.015	56.7	40.9	2.7
Do	2725	60.4	20.7	17.7	1.0	1,135	52.3	44.7	2.5
Do	2726	65.2	19.9	14.2	.9	915	57 3	40.7	2.7
Do	2727	62.3	17.6	19.3	.9	1.135	46.8	51.1	2.4
Do	2728	65.9	18.4	14.7	.9	955	54.1	43.2	2.6
Average	....	63.3	19.1	17.0	.9	1.060	53.0	45.6	2.5

An examination of the above tables emphasizes the following points in a marked degree: (1) The range of variation in the amount of protein in the different chickens is much less than in the amount of fat. The extreme range of protein in the edible portion is from 15.4 to 21.8, averaging 19.1 per cent. (2) The range in the amount of fat is very great, the maximum value (28.3) being nearly three times the minimum (9.7), with an average of 17 per cent. (3) The fluctuations in the amount of fat follow almost exactly the fluctuations in the amount of water, so that the leanest chicken contains the largest proportion of water and an average amount of protein. On the other hand, the fowl with the largest percentage of fat and nearly the average amount of protein contains the least water. This relation of fat and water holds true for nearly all kinds of flesh which have been analyzed.

COMPARATIVE COST OF BEEF AND CHICKEN.

The average dressed weight of the twenty chickens analyzed, not including gizzard, heart, and liver, was 2¼ pounds, their cost 25 cents each. This is equivalent to 11 cents a pound as purchased, or 40 cents a pound for the water-free nutrients of the flesh. Taking the results of the analyses of thirty-four samples of beef rib, round, and sirloin, analyzed in 1895,[1] the cost of one pound of water-free flesh would be 37 cents, on the assumption that the average cost of these cuts in the market is 10 cents a pound. This would indicate a difference of 3 cents in favor of beef. It should be borne in mind, however, that as a rule there is less waste in chicken than in beef, owing to its greater freedom from tendons and cartilage (gristle). If the prices quoted above can be considered as fairly representative of chicken and beef in Tennessee and neighboring States, too much prominence can not be given to chicken as an article of food in the South.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 29.

THE DIETARY STUDIES.

The plan of these studies was the same as that described in the report of the work done at the University of Tennessee during the year 1895.[1] It includes the accurate determination of the amounts and kinds of different food materials purchased and consumed during a given period, usually from seven to thirty days, by a family or boarding club; the collection and analysis of the food wasted. and the record of the age, sex, and occupation of the different persons making up the family or club, and the number of meals taken by each. From the amounts of the different food materials consumed and the composition of each material, as determined by actual analysis or as assumed from tables of average composition, the actual amounts of nutrients contained in the food were calculated. From these are deducted the amount of nutrients in the waste.

As a rule a woman requires less food than a man, and the amount required by children is still less, varying with the age. It is customary to assign certain factors which shall represent the amount of nutrients required by children of different ages and by a woman as compared with an adult man. These factors, which are based in part upon experimental data and in part upon arbitrary assumption, are as follows:

Factors used in calculating meals consumed in dietary studies.

One meal of woman equivalent to 0.8 meal of man at moderate muscular labor.
One meal of boy 14 to 16 years of age. inclusive. equivalent to 0.8 meal of man.
One meal of girl 14 to 16 years of age, inclusive. equivalent to 0.7 meal of man.
One meal of child 10 to 13 years of age. inclusive, equivalent to 0.6 meal of man.
One meal of child 6 to 9 years of age, inclusive. equivalent to 0.5 meal of man.
One meal of child 2 to 5 years of age, inclusive, equivalent to 0.4 meal of man
One meal of child under 2 years of age equivalent to 0.3 meal of man.

By means of the preceding factors it is easy to calculate the number of meals for one man which would be equivalent to those actually eaten by the different persons. This value divided by three gives the equivalent number of days for one man. The total quantity of nutrients consumed divided by the equivalent number of days for one man give the quantities "per man per day," the unit by which dietaries are ordinarily compared.

Cost of food.—In estimating the cost of the food in the individual dietaries the average cost of the different food materials as found in the Knoxville markets has, as a rule, been taken rather than the prices actually paid in the different cases. Where, however. a family or a club paid decidedly more or less than the average, the prices actually paid are used.

Waste.—The words "refuse" and "waste" are used somewhat indiscriminately. In general, refuse in animal food represents inedible material, although bone, tendon, etc., which are classed as refuse, may be utilized for soup. The refuse of vegetable foods, such as parings, seeds, etc., represents not only inedible material, but also more or less of edible material. The waste includes the edible portion of the food, as pieces of meat, bread, etc., which might be saved, but is actually thrown away with the refuse.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 29.

Inasmuch as it was not convenient to separate animal from vegetable waste, the figures given in the tables under "waste" represent both that from animal and vegetable foods. In the dietary studies made at the University of Tennessee in 1895 an attempt was made to roughly calculate how much of this waste was of animal and how much of vegetable origin. The assumptions made were, however, purely arbitrary and in the light of recent experiments do not seem accurate. Consequently no attempt is made in the tables to distinguish the source of the waste.

The value of the waste may be roughly estimated (1) from the proportion of the most expensive ingredient, protein, therein as compared with the amount of food purchased, or (2) from the ratio of the fuel value of the material wasted to that of the food purchased. Either of these methods gives practically the same results. The former has been employed in the following tables.

Composition of food materials.—The food materials used in the largest quantities were sampled and analyzed in connection with the different dietary studies. In the case of a number of foods, particularly those used in small amounts, analysis was not considered necessary. The composition of such food materials was either assumed from averages of analyses of similar Tennessee products, or from averages of analyses of American food materials.[1] When the composition was determined, the analyses were made according to the usual methods, referred to on page 6. The results are given in Table 9. This table gives the composition of the different food materials as they were actually purchased and used.

TABLE 9.—*Percentage composition of food materials analyzed in connection with the dietary studies.*

Kind of food material.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Soup stock		89.1	5.8	1.5		3.6
Veal, leg	6.1	67.3	19.5	6.0		1.1
Pork, spare rib	46.7	23.0	7.1	22.0		1.2
Pork, sausage		39.7	11.8	47.1		1.4
Catfish	19.4	51.7	11.6	16.6		.7
Salmon, canned		67.1	24.3	5.3		3.3
Butter		11.2	1.3	84.5		3.0
Milk		87.7	3.1	3.7	4.8	.7
Corn meal		11.9	9.8	4.0	73.0	1.3
Corn meal, grits		9.4	9.4	1.1	79.6	.5
Flour, Graham		11.6	15.3	2.1	68.3	2.7
Flour, wheat		12.8	10.6	1.0	75.1	.5
Hominy		12.2	9.0	1.0	77.3	.5
Oatmeal		6.3	17.5	7.7	66.7	1.8
Rice		13.6	7.3	.4	78.4	.3
Bread		30.5	10.5	1.3	56.9	.8
Crackers		6.6	14.2	6.4	71.2	1.6
Corn, canned		78.9	2.7	.8	16.9	.7
Tomatoes, canned		94.6	1.3	.3	3.3	.5
Apricots, evaporated		26.4	6.4	1.1	62.7	3.4

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[1] An unpublished revision of U. S. Dept. Agr., Office of Experiment Stations Bul. 28.

DIETARY STUDY OF A MECHANIC'S FAMILY IN TENNESSEE (No. 181).

The family here studied was small, consisting of the father, mother, and two children. The father, 57 years of age, was an engineer at hard work. The mother, 55 years of age, and the daughter of 19 attended to the household duties, and the other child, a boy of 11 years, attended school.

The details of the study are as follows:

The study began February 18, 1896, and continued 14 days. The number of meals taken was as follows:

	Meals.
Man	42
2 women (84 meals × 0. 8 meal of man), equivalent to	67
Boy (42 meals × 0. 6 meal of man), equivalent to	25
Visitor, woman (8 meals × 0. 8 meal of man), equivalent to	6
Boy (5 meals × 0. 7 meal of man), equivalent to	4
Total number of meals taken, equivalent to	144

Equivalent to 1 man 48 days.

TABLE 10.—*Food materials and table and kitchen wastes in dietary study No. 181.*

Kind of food material.	Composition.			Total cost.	Weight used.			
	Protein.	Fat.	Carbohydrates.		Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOOD.								
Pork:	*Per ct.*	*Per ct.*	*Per ct.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*
Spare rib[1]	7. 1	22. 0	....	$0. 50	4, 535	322	998	....
Salt, fat[2]	7. 9	73. 2	....	. 89	6, 745	533	4, 937	....
Lard	....	100. 0	....	. 20	1, 135	....	1, 135	....
Sausage[1]	11. 8	47. 1	....	. 10	905	107	426	....
Bologna	18. 0	19. 7	....	. 20	905	163	178	....
Total	....	....	....	1. 89	14, 225	1, 125	7, 674	....
Poultry: Chicken[2]	14. 1	12. 7	....	. 60	1, 815	256	230	....
Butter[2]	1. 5	82. 8	....	. 70	1, 590	24	1, 316	....
Buttermilk[2]	3. 0	. 6	3. 9	. 20	9, 070	272	54	354
Eggs	13. 3	9. 8	....	. 37	1, 135	151	111	....
Total animal food	....	....	....	3. 76	27, 835	1, 828	9, 385	354
VEGETABLE FOOD.								
Cereals:								
Corn meal[2]	8. 8	3. 7	72. 7	. 32	14, 720	1, 295	545	10, 700
Flour[2]	10. 4	1. 0	76. 4	. 46	9, 410	979	94	7, 189
Total	....	....	....	. 78	24, 130	2, 274	639	17, 889
Sugar and starches: Sugar	....	....	100. 0	. 04	455	....	....	455
Vegetables:								
Beans, dried[1]	21. 4	1. 9	57. 3	. 16	1, 815	388	35	1, 040
Onions	1. 5	. 4	9. 2	. 10	680	10	3	62
Cowpeas, dried[2]	22. 4	1. 6	61. 9	. 08	905	203	15	560
Potatoes (30 per cent refuse)	2. 2	. 1	18. 8	. 45	8, 255	182	8	1, 552
Turnip greens[2]	5. 2	. 8	7. 1	. 35	3, 630	189	29	258
Total	....	......	....	1. 14	15, 285	972	90	3, 472
Fruits: Jelly	1. 1	....	77. 2	. 25	1, 700	19	....	1, 312
Total vegetable food	....	....	....	2. 21	41, 570	3, 265	729	23, 128
Total food	....	....	....	5. 97	69, 405	5, 093	10, 114	23, 482
Table and kitchen waste[1]	11. 5	6. 7	80. 0	....	3, 800	437	255	3, 040

[1] Analyzed in connection with this study.

[2] Composition assumed from analyses of similar Tennessee food materials.

TABLE 11.—*Weights and percentages of food materials and nutritive ingredients used in dietary study No. 181.*

Kind of food material.	Weights.					Percentages of total food.				
	Food material.	Protein.	Fat.	Carbohydrates.	Cost.	Food material.	Protein.	Fat.	Carbohydrates.	Cost.
PER MAN PER DAY.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per c.*	*P. ct.*
Pork, lard, etc	296	23	160			20.5	22.1	75.9		
Poultry	38	5	5			2.6	5.0	2.3		
Eggs	24	3	2			1.6	3.0	1.1		
Butter	33	1	28			2.3	.5	13.0		
Buttermilk	189	6	1	7		13.1	5.3	.5	1.5	
Total animal food	580	38	196	7	8	40.1	35.9	92.8	1.5	63.0
Cereals	503	47	13	373		34.8	44.6	6.3	76.2	
Sugars and starches	10			10		.7			1.9	
Vegetables	318	20	2	72		22.0	19.1	.9	14.8	
Fruits	35	1		27		2.4	.4		5.6	
Total vegetable food	866	68	15	482	4	59.9	64.1	7.2	98.5	37.0
Total food	1,446	106	211	489	12	100.0	100.0	100.0	100.0	100.0

TABLE 12.—*Nutrients and potential energy in food purchased, rejected, and eaten in dietary study No. 181.*

Kind of food.	Weights and fuel value.				Cost.	Percentages of total food.				
	Protein.	Fat.	Carbohydrates.	Fuel value.		Protein.	Fat.	Carbohydrates	Fuel value.	Cost.
PER MAN PER DAY.										
Food purchased:	*Grams.*	*Grams.*	*Grams.*	*Calories.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Animal	38	196	7	2,005	8	35.9	92.8	1.5	45.6	63.0
Vegetable	68	15	482	2,395	4	64.1	7.2	98.5	54.4	37.0
Total	106	211	489	4,400	12	100.0	100.0	100.0	100.0	100.0
Waste	9	5	63	340	1	8.6	2.5	12.9	7.9	8.5
Food actually eaten	97	206	426	4,060	11	91.4	97.5	87.1	92.1	91.5

DIETARY STUDY OF A MECHANIC'S FAMILY IN TENNESSEE (No. 182).

The second dietary study was carried on in a family consisting of a man and his wife, their grown-up son and daughter, a domestic, and one boarder, a man. The father, 60 years of age, was an engineer; his son, 22 years old, was a carpenter; the boarder was a farmer. The mother, aged 45, the daughter, aged 24, and the domestic, aged 33 years, were engaged in household duties or other light work.

The details of the study are as follows:

The study began March 5, 1896, and continued 14 days. The number of meals taken was as follows:

	Meals.
Men	116
Women (103 meals × 0.8 meal of man), equivalent to	82
Visitors (children) equivalent to	1
Total number of meals taken, equivalent to	199

Equivalent to 1 man 66 days.

TABLE 13.—*Food materials and table and kitchen wastes in dietary study No. 182.*

Kind of food material.	Composition.			Total cost.	Weight used.			
	Protein.	Fat.	Carbohydrates.		Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOOD.	*Per ct.*	*Per ct.*	*Per ct.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*
Beef: Shoulder clod[1]	19.3	4.7		$0.32	1,810	349	85	
Pork:								
Shoulder, smoked	12.9	26.6		2.28	14,745	1,902	3,922	
Lard		100.0		.18	1,035		1,035	
Total				2.46	15,780	1,902	4,957	
Fish:								
Catfish[1]	11.6	16.6		.32	1,470	171	244	
Halibut, smoked	19.1	14.0		.10	565	108	79	
Total				.42	2,035	279	323	
Eggs	13.3	9.8		1.86	5,605	746	549	
Butter[1]	1.5	82.8		.88	1,980	30	1,639	
Milk[2]	3.3	4.5	5.1	.70	14,460	477	651	737
Buttermilk[1]	3.0	.6	3.9	.05	2,490	75	15	97
Total animal food				6.69	44,160	3,858	8,219	834
VEGETABLE FOOD.								
Cereals:								
Flour[1]	10.4	1.0	76.4	.45	9,280	965	93	7,090
Oatmeal[1]	17.6	7.5	65.8	.22	2,435	428	183	1,602
Rice	7.8	.4	79.2	.09	565	44	2	448
Crackers[1]	14.2	6.4	71.2	.22	1,245	177	80	886
Total				.98	13,525	1,614	358	10,026
Sugars and starches:								
Sugar			100.0	.10	1,130			1,130
Maple sirup			70.0	.10	680			476
Tapioca	.4	.3	87.5	.02	115			101
Total				.22	1,925			1,707
Vegetables:								
Beans, dried[1]	21.4	1.9	57.3	.33	3,705	793	70	2,123
Cabbage	1.6	.3	4.8	.03	1,360	22	4	65
Corn, canned[2]	2.8	1.3	19.6	1.65	7,470	209	97	1,464
Parsnips (14 per cent refuse)	1.6	.5	13.5	.10	1,020	16	5	138
Potatoes (20 per cent refuse)	2.2	.1	18.8	.75	20,035	441	20	3,766
Tomatoes, canned[1]	1.3	.3	3.3	.14	765	10	2	25
Total				3.00	34,355	1,491	198	7,581
Fruits:								
Raisins	2.2	2.8	64.7	.06	285	6	8	185
Huckleberries, canned[1]	.6	.6	12.8	1.47	6,705	40	40	858
Total				1.53	6,990	46	48	1,043
Total vegetable food				5.73	56,795	3,151	604	20,357
Total food				12.42	100,955	7,009	8,823	21,191
Table and kitchen waste[2]	30.7	20.3	44.0		2,375	729	482	1,045

[1] Composition assumed from analyses of similar Tennessee food materials.
[2] Analyzed in connection with this study.

TABLE 14.—*Weights and percentages of food materials and nutritive ingredients used in dietary study No. 182.*

Kind of food material.	Weights.					Percentages of total food.				
	Food material.	Protein.	Fat.	Carbohydrates.	Cost.	Food material.	Protein.	Fat.	Carbohydrates.	Cost.
PER MAN PER DAY.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Beef, veal, and mutton	27	5	1	....	......	1.8	5.0	1.0	....	......
Pork, lard, etc	239	29	75	....	......	15.6	27.1	56.2	....	......
Fish, etc	31	4	5	....	......	2.0	4.0	3.6	....	......
Eggs	85	11	9	....	......	5.6	10.7	6.2	....	......
Butter	30	1	25	....	......	2.0	.4	18.6	....	......
Milk	219	7	10	11	......	14.3	6.8	7.4	3.5	......
Buttermilk	38	1	....	2	......	2.5	1.0	.2	.4	......
Total animal food	669	58	125	13	10	43.8	55.0	93.2	3.9	53.9
Cereals	205	24	5	152	......	13.4	23.0	4.1	47.3	......
Sugars and starches	29	....	....	26	......	1.9	....	....	8.1	......
Vegetables	521	23	3	114	......	34.0	21.3	2.2	35.8	......
Fruits	106	1	1	16	......	6.9	.7	.5	4.9	......
Total vegetable food	861	48	9	308	9	56.2	45.0	6.8	96.1	46.1
Total food	1,530	106	134	321	19	100.0	100.0	100.0	100.0	100.0

TABLE 15.—*Nutrients and potential energy in food purchased, rejected, and eaten in dietary study No. 182.*

Kind of food.	Weights and fuel value.				Cost.	Percentages of total food.				
	Protein.	Fat.	Carbohydrates.	Fuel value.		Protein.	Fat.	Carbohydrates.	Fuel value.	Cost.
PER MAN PER DAY.										
Food purchased:	*Grams.*	*Grams.*	*Grams.*	*Calories.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Animal	58	125	13	1,450	10	55.0	93.2	3.9	48.4	53.9
Vegetable	48	9	308	1,545	9	45.0	6.8	96.1	51.6	46.1
Total	106	134	321	2,995	19	100.0	100.0	100.0	100.0	100.0
Waste	11	7	16	175	2	10.4	5.5	4.9	5.9	10.4
Food actually eaten	95	127	305	2,820	17	89.6	94.5	95.1	94.1	89.6

DIETARY STUDY OF A STUDENTS' CLUB AT THE UNIVERSITY BOARDING HOUSE (No. 207).

This club consisted of 90 men aged on an average 22 years, 9 women aged on an average 25 years, and 1 child 10 years of age. Of the men, 2 were professors in the university, 87 were students, and there was 1 colored servant. One of the women acted as manager of the boarding club, 3 were boarders, 3 house servants, and 2 colored cooks. The cost of board was $2.50 per week.

The details of the study are as follows:

The study began November 9, 1896, and continued 14 days. The number of meals taken was as follows:

	Meals.
90 men	3, 533
9 women (345 meals × 0.8 meal of man), equivalent to	276
1 child (42 meals × 0.6 meal of man), equivalent to	25
Total number of meals taken, equivalent to	3, 834

Equivalent to 1 man 1,278 days.

TABLE 16.—*Food materials and table and kitchen wastes in dietary study No. 207.*

Kind of food material.	Composition.			Total cost.	Weight used.			
	Protein.	Fat.	Carbohydrates.		Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOOD.								
Beef:	*Per ct.*	*Per ct.*	*Per cent.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*
Brisket[1]	11. 4	18. 1	....	$2. 88	26, 085	2, 973	4, 720	....
Chuck rib (edible portion)[1]	19. 9	8. 6	....	8. 39	63, 390	12, 615	5, 451	....
Sirloin steak[1]	16. 4	14. 7	....	12. 97	73, 540	12, 061	10, 810	....
Round steak[1]	19. 9	7. 0	....	14. 12	80, 060	15, 932	5, 604	....
Shoulder clod (as purchased)[1]	19. 3	4. 7	....	1. 76	15, 990	3, 086	751	....
Standing rib (edible portion)[1]	17. 6	24. 4	....	4. 37	33, 000	5, 808	8, 052	....
Soup stock[2]	5. 8	1. 5	....	....	154, 565	8, 965	2, 318	....
Liver	20. 9	5. 0	1. 6	. 28	2, 495	521	125	40
Gelatin	84. 2	. 1	....	4. 60	650	547	1	....
Total	....	....	....	49. 37	449, 775	62. 508	37, 832	40
Veal leg[2]	19. 5	6. 0	....	13. 14	74, 505	14, 529	4, 470	....
Pork:								
Spare rib[1]	7. 1	22. 0	....	3. 92	25, 400	1, 803	5, 588	....
Salt pork, fat[1]	7. 9	73. 2	....	. 30	2, 270	179	1, 662	....
Lard	....	100. 0	....	3. 38	26, 935	....	26, 935	....
Total	....	....	....	7. 60	54, 605	1, 982	34, 185	....
Poultry: Fowl[1]	14. 1	12. 7	....	4. 09	14, 855	2, 094	1, 886	....
Fish:								
Catfish[2]	11. 6	16. 6	....	5. 00	22, 680	2, 631	3, 765	....
Salmon, canned[2]	24. 3	5. 3	....	7. 02	16, 430	3, 992	871	....
Total	....	....	....	12. 02	39, 110	6, 623	4, 636	....
Eggs[1]	13. 3	9. 8	....	2. 47	56, 050	7, 454	5, 493	....
Butter[2]	1. 3	84. 5	....	33. 35	75, 640	983	63, 916	....
Milk[2]	3. 1	3. 7	4. 8	29. 80	636, 060	19, 718	23, 534	30, 531
Total animal food	....	....	....	151. 84	1, 400, 600	115, 891	175, 952	30, 571
VEGETABLE FOOD.								
Cereals:								
Corn meal[2]	9. 8	4. 0	73. 0	. 84	42, 410	4, 156	1, 697	30, 959
Corn meal grits[2]	9. 4	1. 1	79. 6	. 34	10, 320	970	114	8, 214

[1] Average of similar Tennessee food materials.

[2] Analyzed in connection with this study.

TABLE 16.—*Food materials and table and kitchen wastes in dietary study No. 207*—Cont'd.

Kind of food material.	Composition.			Total cost.	Weight used.			
	Protein.	Fat.	Carbohydrates.		Total food material.	Protein.	Fat.	Carbohydrates.
VEGETABLE FOOD—cont'd.								
Cereals—Continued.	*Per ct.*	*Per ct.*	*Per cent.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*
Flour, Graham[1]	15.3	2.1	68.3	$4.20	6,915	1,058	145	4,722
Flour, wheat[1]	10.6	1.0	75.1	9.82	151,275	16,035	1.513	113,607
Hominy[1]	9.0	1.0	77.3	.15	4,535	408	45	3,505
Oatmeal[1]	17.5	7.7	66.7	2.84	42,865	7,501	3.301	28,591
Rice[1]	7.3	.4	78.4	1.29	10,660	778	43	8,357
Bread[1]	10.5	1.3	56.9	3.32	50,235	5,275	653	28.584
Crackers[1]	14.2	6.4	71.2	4.20	38,045	5,402	2,435	27,088
Total	....	....	....	27.00	357,260	41,583	9,946	253,627
Sugar and starches:								
Chocolate	12.9	48.7	30.3	.65	1,475	190	718	447
Molasses	2.4	....	69.3	2.56	36,260	870	....	25,128
Sugar, granulated	....	....	100.0	16.31	164,430	....	....	164,430
Cornstarch	....	....	93.8	.60	2,720	....	....	2,551
Tapioca	.4	.3	87.5	.32	2,040	8	6	1,785
Total	....	....	....	20.44	206,925	1,068	724	194,341
Vegetables:								
Beans, dried	22.4	1.8	59.1	.35	6,350	1,422	114	3.753
Cabbage	1.6	.3	4.8	.84	25,290	404	76	1,214
Celery	1.3	.1	3.8	.75	905	12	1	34
Lettuce	1.1	.3	2.7	.23	11,680	129	35	315
Potatoes (34 per cent refuse)	2.2	.1	18.8	3.73	134,305	2,955	134	25,249
Sweet potatoes (35 per cent refuse)	1.8	.7	27.4	2.24	87,230	1,570	571	23,901
Turnips (34 per cent refuse)	1.3	.2	8.1	.41	24,475	318	49	1,982
Pickles and chowchow	1.1	.4	4.0	1.68	29,050	320	116	1,162
Corn, canned[1]	2.7	.8	16.9	.85	8,630	233	69	1,458
Tomatoes, canned[1]	1.3	.3	3.3	2.60	36,885	479	111	1,217
Total	....	....	....	13.68	364,800	7,842	1,276	60,285
Fruits:								
Apples (27 per cent refuse)	.4	.5	15.2	3.87	98,510	394	493	14,973
Bananas	.7	.4	13.2	.48	5,105	36	20	674
Cranberries	.4	.6	9.9	.42	4.765	19	29	471
Figs	4.3	.3	74.2	.97	5,500	236	17	4,081
Grapes (25 per cent refuse)	1.3	1.6	19.2	1.62	18,370	239	294	3,527
Oranges	.6	.4	7.1	.18	1,020	6	4	72
Prunes	2.4	1.3	58.5	1.22	7,370	177	96	4,311
Currants, dried	2.4	1.7	74.2	.15	680	16	12	505
Pears and peaches, canned	.5	.2	7.5	7.21	24,835	124	50	1,862
Peaches, apricots, and pears, evaporated[1]	6.4	1.1	62.7	1.78	10,030	642	110	6,289
Total	....	....	....	17.90	176,185	1,889	1,125	36.765
Total vegetable food	....	....	....	79.02	1,105.170	52,382	13,071	545.018
Total food	....	....	....	230.86	2,505,770	168,273	189.023	575,589
Table and kitchen waste[1]	25.7	17.6	51.9	....	43,160	11,092	7,596	22,400
Clear fat	....	100.0	....	....	410	....	410	....
Total	....	....	....	....	43,570	....	....	....

[1] Analyzed in connection with this study.

TABLE 17.—*Weights and percentages of food materials and nutritive ingredients used in dietary study No. 207.*

Kind of food material.	Weights.					Percentages of total food.				
	Food material.	Protein.	Fat.	Carbohydrates.	Cost.	Food material.	Protein.	Fat.	Carbohydrates.	Cost.
PER MAN PER DAY.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Beef, veal, and mutton	410	60	33	....	......	21.0	45.8	22.4	....	......
Pork, lard, etc	43	2	27	....	......	2.2	1.2	18.1	....	......
Poultry	12	2	2	....	......	.6	1.3	1.0	....	......
Fish, etc	30	5	4	....	......	1.6	3.9	2.4	....	......
Eggs	44	6	4	....	......	2.2	4.4	2.9	....	......
Butter	59	1	50	....	......	3.0	.6	33.8	....	......
Milk	498	15	18	24	......	25.3	11.7	12.5	5.3	......
Total animal food	1,096	91	138	24	12	55.9	68.9	93.1	5.3	65.8
Cereals	280	33	8	199	......	14.3	24.7	5.2	44.1	......
Sugars and starches ..	162	1	....	152	......	8.2	.6	.4	33.7	......
Vegetables	285	6	1	47	......	14.6	4.7	.7	10.5	......
Fruits	138	1	1	29	......	7.0	1.1	.6	6.4	......
Total vegetable food	865	41	10	427	6	44.1	31.1	6.9	94.7	34.2
Total food	1,961	132	148	451	18	100.0	100.0	100.0	100.0	100.0

TABLE 18.—*Nutrients and potential energy in food purchased, rejected, and eaten in dietary study No. 207.*

Kind of food.	Weights and fuel value.				Cost.	Percentages of total food.				Cost.
	Protein	Fat.	Carbohydrates.	Fuel value.		Protein.	Fat.	Carbohydrates.	Fuel value.	
PER MAN PER DAY.										
Food purchased:	*Grams.*	*Grams.*	*Grams.*	*Calories*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Animal	91	138	24	1,750	12	68.9	93.1	5.3	46.5	34.2
Vegetable	41	10	427	2,010	6	31.1	6.9	94.7	53.5	65.8
Total	132	148	451	3,760	18	100.0	100.0	100.0	100.0	100.0
Waste	9	6	18	165	1	6.6	4.2	3.9	4.4	6.6
Food actually eaten	123	142	433	3,595	17	93.4	95.8	96.1	95.6	93.4

DIETARY STUDY OF A STUDENTS' CLUB AT THE UNIVERSITY FARM (No. 208).

This club consisted of 13 men aged on an average 25.4 years, 5 women aged on an average 32 years, and 1 child 7 years of age. The young men were mainly students of agriculture, and the majority of them worked a portion of the time on the college farm, receiving compensation for their labor. One of the students acted in the capacity of steward, purchasing all the food and looking out for the interests of the club. The young men were natives of Tennessee, sons of farmers of the better class who live in comfortable circumstances, and residing for the most part in the country districts and small towns. The rate of board was $2 per week. One of the women was the matron of the club, 1 was a helper, 1 a cook, and 2 were visitors.

The details of the study are as follows:

The study began December 8, 1896, and continued 14 days. The number of meals taken was as follows:

	Meals.
13 men	371
5 women (113 meals × 0.8 meal of man), equivalent to	90
1 child (5 meals × 0.5 meal of man), equivalent to	3
Total number of meals taken equivalent to	464

Equivalent to 1 man 155 days.

TABLE 19.—*Food materials and table and kitchen wastes in dietary study No. 208.*

Kind of food material.	Composition.			Total cost.	Weight used.			
	Protein.	Fat.	Carbohydrates.		Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOOD.	*Per ct.*	*Per ct.*	*Per cent.*		*Grams.*	*Grams.*	*Grams.*	*Grams.*
Beef: Round steak[1]	19.9	7.0	....	$0.46	2,610	519	183	....
Pork:								
Ham, fresh	11.7	36.0	....	1.20	5,445	637	1,960	....
Head	3.8	13.9	....	.10	1,505	57	209	....
Shoulder, fresh	10.4	20.7	....	.25	2,270	236	470	....
Sausage[1]	11.8	47.1	....	.39	3,545	418	1,670	....
Lard	....	100.0	....	1.68	12,700	....	12,700	....
Total	....	....	....	3.62	25,465	1,348	17,009	....
Poultry: Fowl[1]	14.1	12.7	....	1.18	4,280	603	544	....
Eggs	13.3	9.8	....	.09	1,995	265	196	....
Butter[1]	1.5	82.8	....	3.09	7,005	105	5,800	....
Milk	3.3	4.0	5.0	.93	19,730	651	789	987
Buttermilk[1]	3.0	.6	3.9	.16	7,090	213	43	276
Total animal food	....	....	....	9.53	68,175	3,704	24,564	1,263
VEGETABLE FOOD.								
Cereals:								
Corn meal[1]	8.8	3.7	72.7	.06	2,720	239	101	1,977
Corn meal, grits[1]	9.0	1.2	78.2	.11	3,430	309	41	2,682
Flour[1]	10.4	1.0	76.4	2.96	46,265	4,812	463	35,346
Oatmeal[1]	17.6	7.5	65.8	.20	3,005	529	225	1,977
Rice	7.8	.4	79.2	.41	3,400	265	14	2,693
Bread	9.4	1.2	53.0	.25	3,800	357	46	2,014
Cake	6.9	8.7	62.0	.70	1,590	110	138	986
Crackers[1]	14.2	6.4	71.2	.03	225	32	14	160
Total	....	....	....	4.72	64,435	6,653	1,042	47,835
Sugars and starches:								
Sugar, granulated	....	....	100.0	1.28	12,930	....	....	12,930
Molasses	2.4	....	69.3	.10	1,390	34	....	963
Total	....	....	....	1.38	14,320	34	....	13,893
Vegetables:								
Cabbage	1.6	.3	4.8	.15	4,650	74	14	223
Celery	1.3	.1	3.8	.93	1,135	15	1	43
Onions	1.5	.4	9.2	.03	595	9	2	55
Sweet potatoes (20 per cent refuse)	1.8	.7	27.4	.04	1,885	34	13	517
Potatoes (25 per cent refuse)	2.2	.1	18.8	.48	19,730	434	20	3,709
Radishes	.9	.1	4.1	.04	340	3	1	14
Turnips (30 per cent refuse)	1.3	.2	8.1	.05	3,175	41	7	257
Total	....	....	....	1.72	31,510	610	58	4,818
Fruits:								
Apples (25 per cent refuse)	.4	.5	15.2	2.57	6,720	27	34	1,021
Cranberries	.4	.6	9.9	.13	1,505	6	9	149
Grapes and blackberries, canned	.8	2.1	56.4	1.34	4,085	33	86	2,304
Plums, preserved	.3	2.4	54.4	2.58	5,870	18	141	3,193
Total	....	....	....	6.62	18,180	84	270	6,667
Total vegetable food	....	....	....	14.44	128,445	7,381	1,370	73,213
Total food	....	....	....	23.97	196,620	11,085	25,934	74,476
Table and kitchen waste[2]	12.3	24.3	59.8	....	7,775	956	1,889	4,649

[1] Average of similar Tennessee food materials.

[2] Analyzed in connection with this study.

TABLE 20.—*Weights and percentages of food materials and nutritive ingredients used in dietary study No. 208.*

Kind of food material.	Weights.				Cost.	Percentages of total food.				Cost.
	Food material.	Protein.	Fat.	Carbohydrates.		Food material.	Protein.	Fat.	Carbohydrates.	
PER MAN PER DAY.										
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Beef, veal, and mutton	17	3	1			1.3	4.7	0.7		
Pork, lard, etc	164	9	110			13.0	12.2	65.6		
Poultry	28	4	4			2.2	5.4	2.1		
Eggs	13	2	1			1.0	2.4	.7		
Butter	45	1	37			3.6	.9	22.4		
Milk	127	4	5	6		10.0	5.9	3.0	1.3	
Buttermilk	46	1		2		3.6	1.9	.2	.4	
Total animal food	440	24	158	8	6	34.7	33.4	94.7	1.7	39.8
Cereals	416	43	7	309		32.8	60.0	4.0	64.2	
Sugars and starches	93			90		7.3	.3		18.7	
Vegetables	203	4		31		16.0	5.5	.2	6.5	
Fruits	117	1	2	43		9.2	.8	1.1	8.9	
Total vegetable food	829	48	9	473	9	65.3	66.6	5.3	98.3	60.2
Total food	1,269	72	167	481	15	100.0	100.0	100.0	100.0	100.0

TABLE 21.—*Nutrients and potential energy in food purchased, rejected, and eaten in dietary study No. 208.*

Kind of food.	Weights and fuel value.				Cost.	Percentages of total food.				
	Protein.	Fat.	Carbohydrates.	Fuel value.		Protein.	Fat.	Carbohydrates.	Fuel value.	Cost.
PER MAN PER DAY.										
Food purchased:	*Grams.*	*Grams.*	*Grams.*	*Calories.*	*Cents.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*
Animal	24	158	8	1,600	6	33.4	94.7	1.7	42.0	39.8
Vegetable	48	9	473	2,220	9	66.6	5.3	98.3	58.0	60.2
Total	72	167	481	3,820	15	100.0	100.0	100.0	100.0	100.0
Waste	6	12	30	260	1	8.6	7.3	6.2	6.8	8.6
Food actually eaten	66	155	451	3,560	14	91.4	92.7	93.8	93.2	91.4

DISCUSSION OF RESULTS.

Two of the studies here reported represent the food consumption of families of mechanics who were engaged in more or less active muscular work. It seems fair to assume that the work was moderately severe. Two are of clubs of college students; that is, of young men engaged in mental rather than muscular exercise. For purposes of comparison the results of the dietary studies of mechanics' families and college clubs here reported, and those of similar studies reported previously,[1] are summarized in Tables 22 and 23. In Table 22 are shown the costs of the food and total amounts of protein and fuel value per man per day in the different dietaries. The proportion of the total cost, total protein, and total fuel values in the animal and in the vegetable food materials are also stated. In Table 23 comparisons are made between the proportions of food eaten and that thrown away in the different dietaries.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 29.

TABLE 22.—*Costs, amounts of protein and fuel value of total food, and proportions in animal and vegetable foods as purchased in the Tennessee, as compared with other dietaries.*

[Amounts per man per day.]

	Cost.	Protein.	Total value.	Proportion of total cost.		Proportion of total protein.		Proportion of total fuel value.	
				In animal food.	In vegetable food.	In animal food.	In vegetable food.	In animal food.	In vegetable food.
DIETARIES OF COLLEGE CLUBS.	*Cts.*	*Grams.*	*Calories.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
In Tennessee (No. 39)	18	109	3,870	54.2	45.8	50.7	49.3	40.1	59.9
In Tennessee (No. 40)	18	106	3,760	59.3	40.7	52.4	47.6	37.2	62.8
In Tennessee (No. 41)	19	98	3,880	57.1	42.9	48.5	51.5	36.2	63.8
In Tennessee (No. 207)	18	132	3,760	34.2	65.8	68.9	31.1	46.5	53.5
In Tennessee (No. 208)	15	72	3,820	39.8	60.2	33.4	66.6	42.0	58.0
Average 5 clubs in Tennessee	18	103	3,820	48.9	51.1	50.8	49.2	40.4	59.6
Average 5 clubs in Connecticut[1]	.....	127	3,880	....	....	67.7	32.3	53.2	46.8
Average 5 clubs in Maine[2]	27	159	5,440	70.4	29.6	62.9	37.1	47.5	52.5
Average 3 clubs in Missouri[3]	.....	107	3,920	....	....	58.9	41.1	49.2	50.8
DIETARIES OF MECHANICS' FAMILIES.									
In Tennessee (No. 42)	16	119	4,435	66.7	33.3	52.9	47.1	52.1	47.9
In Tennessee (No. 181)	12	106	4,400	63.0	37.0	35.9	64.1	45.6	54.4
In Tennessee (No. 182)	19	106	2,995	53.9	46.1	55.0	45.0	48.4	51.6
Average 3 families in Tennessee	16	110	3,945	61.2	38.8	47.9	52.1	48.7	51.3
Average 9 families in Connecticut[1]	.....	113	3,605	....	....	61.1	38.9	47.9	52.1
A family in New Jersey[4]	28	103	3,530	53.6	46.4	60.2	39.8	44.1	55.9
A family in Indiana[5]	26	106	3,840	50.0	50.0	58.5	41.5	42.7	57.3

[1] Connecticut Storrs Sta. Rpt. 1896, p. 152.
[2] U. S. Dept. Agr., Office of Experiment Stations Bul. 37.
[3] U. S. Dept. Agr., Office of Experiment Stations Bul. 31.
[4] U. S. Dept. Agr., Office of Experiment Stations Bul. 35.
[5] U. S. Dept. Agr., Office of Experiment Stations Bul. 32.

TABLE 23.—*Protein and fuel value, and estimated costs of the food actually eaten and of that wasted in the Tennessee, as compared with other dietaries.*

[Amounts per man per day.]

	Waste.			Food eaten.		
	Estimated cost.	Protein.	Fuel value.	Estimated cost.	Protein.	Fuel value.
DIETARIES OF COLLEGE CLUBS.	*Cents.*	*Grams.*	*Calories.*	*Cents.*	*Grams.*	*Calories.*
In Tennessee (No. 39)	3	16	390	15	93	3,480
In Tennessee (No. 40)	2	13	310	16	93	3,450
In Tennessee (No. 41)	2	10	245	17	88	3,635
In Tennessee (No. 207)	1	9	165	17	123	3,595
In Tennessee (No. 208)	1	6	260	14	66	3,560
Average 5 clubs in Tennessee	2	11	275	16	92	3,545
Average 5 clubs in Connecticut	....	21	575	....	106	3,280
Average 5 clubs in Maine	6	38	1,180	21	121	4,260
Average 3 clubs in Missouri	....	11	360	....	96	3,560
DIETARIES OF MECHANICS' FAMILIES.						
In Tennessee (No. 42)	2	9	345	14	110	4,090
In Tennessee (No. 181)	1	9	340	11	97	4,060
In Tennessee (No. 182)	2	11	175	17	95	2,820
Average 3 families in Tennessee	2	10	285	14	101	3,660
Average 9 families in Connecticut	....	7	185	....	106	3,420
A family in New Jersey	1	3	95	27	100	3,435
A family in Indiana	4	16	555	22	90	3,285

As the tables show, the amount of protein actually consumed per man per day by the college club at Knoxville was quite variable, ranging from 66 to 123 grams, with an average of 92 grams. The available energy or fuel value of the food actually consumed was much more uniform, the range being from 3,450 to 3,635 calories, and the average 3,545 calories per man per day. The daily waste of protein averaged 11 grams, or about 11 per cent of the total amount purchased, while the waste of fuel ingredients averaged about 7 per cent of the total amount in the food purchased.

The proportions of protein in the dietaries of the mechanics' families were a little larger than those of the students' club. The same was true of the fuel values. The proportions of waste were not far from the same as in the college clubs.

It will be seen that the averages of the protein and energy in the dietaries of the college clubs and families in Tennessee do not differ very greatly from the same factors in the dietaries of students' clubs and workingmen's families in similar circumstances studied elsewhere.

The commonly accepted dietary standard for a man at light work calls for 112 grams of protein and a fuel value of 3,000 calories; that for a man at moderate muscular work for 125 grams of protein and a fuel value of 3,500 calories. In general the results cited above show somewhat less protein and somewhat more energy than the standard. It is, however, known that within limits a deficiency of protein may be made good by an abundance of fat and carbohydrates, i. e., energy.

DIGESTION EXPERIMENTS WITH MEN.

INTRODUCTION.

The value of food for nutriment depends not only upon the kinds and total amounts of nutrients it contains, but also upon the proportion of the nutrients which can be utilized in the body. In order that the food may be utilized it must be digested—that is, it must undergo chemical changes by which it is made capable of absorption. These changes take place with the aid of the various digestive secretions—i. e., the saliva, gastric juice, pancreatic juice, etc. Such portions of the food as resist the action of the digestive ferments and of the bacteria in the intestine are rejected in the feces.

It has been customary to treat the dry matter of the feces as a measure of the amounts of nutrients contained in the food eaten which have resisted the process of digestion. This involves an error, for the reason that the feces contain not only the undigested and incompletely digested residues of the food, but also a considerable amount of other materials commonly called metabolic products. These metabolic products consist chiefly of residues of the bile, mucus, and the gastric, pancreatic, and other digestive secretions, but they include other materials, such as epithelial débris from the intestinal walls.

To determine the exact quantities of nutrients digested it would be necessary to determine and make correction for the metabolic products, and numerous attempts have been made to elaborate methods for quantitative separation of the undigested food residues and the metabolic products of the intestinal secretions. While much valuable work has been done in this line, the methods are not yet as perfect as might be desired, and most investigators continue to follow the ordinary plan of taking the difference between the food and feces as the measure of the digestibility of the food.

While recent investigation indicates that the metabolic products make a much larger proportion of the intestinal secretion than has generally been assumed in the past, the error introduced by neglecting them in determining digestibility is not so great as might be supposed. The metabolic products represent material which, for the most part, has been used for the purposes of the digestion. In other words, they are not available to the body for the yielding of energy, nor can they be utilized for building tissue or protecting it from waste. They are, therefore, unable to perform the principal functions of food. In the sense that they are not available for either building or repair of body material or for the yielding of energy, it is not improper to class them with the undigested residue of the food. This is equivalent to saying that the difference between the feces and food may be taken as measuring the amount which is actually available to the body for the main purposes of nutrition. Viewing the subject in this light, and using the term digestibility in the sense of availability, the proportion of the food which is digested will be its total amount less the sum of the undigested residues and the metabolic products which are involved in the digestive process. This is practically equivalent to the current method and is the plan followed in the experiments here described.

To determine the digestibility of a given food material by the above method it must be either eaten alone or with other material the digestibility of which, under the given conditions, is exactly known. Many experiments have been made with men and domestic animals to determine the digestibility of individual food materials when eaten alone. With domestic animals this may present no great difficulty. An ox, for example, will feed contentedly upon hay alone for an indefinite time; but with man the case is different, since any single food material soon becomes unpalatable and in the attempt to live upon it alone the digestive processes may be disturbed. In experiments with mixed diet these processes are much more likely to be normal. The results of such experiments with mixed diet, together with those of experiments upon the digestibility of individual food materials, give data for the computing of the digestibility of different classes of food materials.[1] The experiments here described were made with mixed diet more or less varied.

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[1] See article on The Digestibility of Different Classes of Food Materials, by W. O. Atwater, in the Connecticut Storrs Sta. Rpt. 1896, pp. 186–189.

THE DETAILS OF THE EXPERIMENTS.

Twenty-one experiments were made in all. Of these thirteen were carried on during the winter of 1895–96 and eight the following season. There were two and sometimes three or four subjects, each receiving the same diet as regards kinds of food materials, but the quantities of each material were such as best suited the individual. One set of analyses thus sufficed for two or more experiments. The solid and liquid excreta were collected for the whole experiment and each sampled and analyzed according to the usual methods.

Each experiment began with breakfast and ended with supper the day following, making six meals, or two whole days. Perhaps this is too short a time to give the most accurate results, but in some cases it was as long as the subjects could comfortably continue the ration, and in one instance it was with difficulty that even six meals were taken.

The supper preceding each experiment consisted largely or wholly of bread and milk, with about half a gram of charcoal. The charcoal colored the feces, and the bread and milk gave a distinctive consistency, so that in this way a very sharp separation could, as a rule, be made between the feces belonging to the experiment and those belonging to the food preceding. The separation at the close was made in a similar manner, the charcoal being taken for breakfast on the day following the completion of the experiment.[1]

COMPOSITION OF FOOD AND FECES.

The percentage composition of all the food materials used in the digestion experiments and of the feces is given in Table 24. The figures given in this table, with the exception of those for the feces, are on the basis of the fresh substance free from refuse. The protein is obtained in all cases by multiplying the nitrogen by the factor 6.25. The heats of combustion were obtained by the bomb calorimeter, the combustions being made at Wesleyan University, Middletown, Conn. The composition of the feces is calculated on the water-free basis.

THE TABULAR RECORDS OF THE EXPERIMENTS.

Tables 25–45 give the data of the individual experiments. The total nutrients in each food material are obtained by multiplying the total weight of each food used by its percentage composition as given in Table 24. The total of each kind of nutrient in the food, less the corresponding undigested matter of the feces, gives the amount digested. The ratio of the amount digested to the total eaten is called the coefficient of digestibility and is usually expressed in percentages.

The total heat of combustion (potential energy) of the food eaten, less that of the feces, does not, however, give a true measure of the energy of the food that is available for use in the body. The reason for this is apparent when we take into account the potential energy of the organic matter eliminated in the urine. This organic matter consists chiefly of urea, but with a considerable amount of other compounds. In order, then, to obtain the actual amount of energy furnished by the food that is available for use in the body, allowance must be made not only for the fuel value of the solid but also of the liquid excreta.

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[1] For a further discussion of this subject see U. S. Dept. Agr., Office of Experiment Stations Bul. 21, pp. 53–80.

In 13 actual determinations, made in connection with metabolism experiments carried on at Middletown, Conn., the average heat of combustion of one gram of the dried and ash-free residue of urine was found to be 2.87 calories and the nitrogen content 0.34 of a gram. This amount of nitrogen may be assumed to have resulted from the consumption of 2.13 grams of protein (0.34 grams nitrogen × 6.25 = 2.13 grams protein). According to this assumption the unavailable energy from one gram of digested protein would amount to 2.87 ÷ 2.13, or 1.35 calories.

The factor 1.35 is, accordingly, used in the following tables for the calculation of the energy of the digested protein which is carried away in the unoxidized organic matter of the urine, and hence is not available to the body. The total energy of the digested protein, less that of this unoxidized residue, is taken as the actual or net fuel value of the digested protein. For instance, in Experiment No. 18 (Table 27) the protein digested was 270 grams. This multiplied by 1.35 gives 365 calories, which is the estimated heat of combustion of the unoxidized residue of the 270 grams of digested protein. The total heat of combustion of the food eaten was 7,504 calories. Subtracting the heat of combustion of the feces, 246 calories, leaves 7,258 calories as the heat of combustion of the digested food. Subtracting from this last the 365 calories, which are estimated to represent the heat of combustion of the protein residue eliminated in the urine, there remain 6,893 calories as the net energy of the food oxidized. This is taken as the net fuel value of the food in this experiment. How these estimates would be affected by the gain or loss of body material during the experiment is a matter which would be more properly discussed in connection with respiration calorimeter experiments.

TABLE 24.—*Percentage composition of food materials and of feces in the digestion experiments here reported.*

Lab. No.	Material.	Water.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion per gram determined.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
113	Beef	72.29	20.44	5.69	....	1.10	1.685
115	do	71.58	19.37	6.99	....	1.07	1.780
205	Corned beef (canned)	52.41	22.00	22.26	....	3.22	3.225
258	Canned beef	57.32	27.19	11.70	....	4.42	2.519
255	Boiled ham	63.39	22.22	7.84	....	6.55	1.877
144	Eggs	74.40	13.19	10.18	....	.98	1.722
101	Milk	88.31	2.89	3.51	4.64	.65	.674
102	do	88.16	3.09	3.70	4.42	.63	.708
106	do	87.15	3.24	4.42	4.54	.65	.744
107	do	86.33	3.39	4.86	4.72	.70	.805
140	do	86.42	3.25	4.47	5.14	.72	.771
141	do	87.33	3.25	3.71	5.00	.71	.735
201	do	86.60	3.31	4.30	5.09	.70	.778
202	do	86.44	3.38	4.51	4.96	.71	.784
242	do	87.29	3.56	3.07	5.33	.75	.776
243	do	86.20	3.38	4.82	4.87	.73	.857
252	do	84.95	3.43	5.13	5.80	.69	.863
253	do	86.13	2.96	5.08	5.17	.66	.801
203	Oatmeal	6.97	19.09	7.82	64.42	1.70	4.210
245	do	8.44	17.00	7.40	65.40	1.76	4.043
246	Wheatlet	8.85	13.24	2.18	74.59	1.14	3.688
103	Bread	27.10	9.88	1,68	60.28	1.06	3.164
108	do	32.92	9.02	1.31	55.73	1.02	2.871
114	do	30.97	9.60	1.73	56.70	1.00	3.057
142	do	31.62	10.14	1.40	55.79	1.05	2.947
204	do	31.02	10.04	1.11	56.84	.99	2.906
244	do	33.53	10.20	1.25	54.12	.90	2.899
254	do	34.77	9.68	1.37	52.87	1.31	2.870
......	Molasses	26.90	....	....	73.10	....	2.997
......	Sugar	....	....	....	100.00	....	4.100
257	Corn, canned	76.67	2.74	1.12	18.94	.53	1.011
256	Saratoga chips	2.62	6.00	44.19	42.68	4.51	5.981
206	Bananas	77.16	1.26	.72	20.14	.72	.827
105	Feces	....	27.28	14.59	28.93	29.20	4.542
104	do	....	20.30	13.30	38.40	28.00	5.324
110	do	....	22.08	12.14	35.57	30.21	4.915
109	do	....	19.10	18.62	33.05	29.23	5.307
117	do	....	47.05	16.99	24.91	11.05	5.532
118	do	....	45.66	11.22	29.10	14.02	4.813
146	do	....	30.08	21.53	21.21	27.18	4.779
147	do	....	29.69	16.98	32.31	21.02	5.388
148	do	....	22.82	24.61	26.45	26.12	5.510
149	do	....	26.20	25.21	28.66	19.93	5.855
208	do	....	27.15	14.04	27.71	31.10	4.471
209	do	....	23.60	17.05	32.93	26.42	5.036
210	do	....	32.55	20.33	30.21	16.91	5.369
247	do	....	24.26	12.97	35.49	27.28	4.876
248	do	....	29.12	23.73	26.14	21.01	5.214
249	do	....	29.18	12.10	31.01	27.71	4.320
250	do	....	22.04	18.56	29.38	30.02	4.862
259	do	....	24.20	13.81	36.14	25.85	5.096
260	do	....	29.22	22.15	30.92	17.71	4.998
261	do	....	27.42	13.40	31.48	27.70	1.111
262	do	....	21.26	28.48	21.40	28.86	4.948

DIGESTION EXPERIMENT No. 16.

Kind of food.—Bread and milk.

Subject.—Chemist, 26 years of age, with a moderate amount of exercise. (Same subject as in Nos. 18, 20, 22, 26, 31, and 34.)

Weight.—(Without clothes) 141 pounds, both at the beginning and the end of the experiment.

Duration.—Two days with six meals, beginning with breakfast. November 22, 1895.

Table 25.—*Results of digestion experiment No. 16.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
101	Milk	2,568	283	74	90	119	17	1,731
102	Milk	2,500	280	77	92	111	16	1,770
103	Bread	1,326	952	131	22	799	14	4,195
	Total		1,515	282	204	1,029	47	7,696
105	Feces, water-free	24.5	17	7	3	7	7	111
	Amount digested		1,498	275	201	1,022	40	7,585
	Per cent digested		98.9	97.5	98.5	99.3	85.1	
	Estimated heat of combustion of urine							371
	Net energy of food oxidized							7,214
	Per cent energy utilized							93.7

There were some slight feelings of hunger during the two days of the experiment. The line of demarcation in the feces was not sharp, and in consequence it is probable that the apparent digestibility is somewhat too high.

DIGESTION EXPERIMENT No. 17.

Kind of food.—Bread and milk.

Subject.—Chemist, 25 years of age, with almost no exercise. (Same subject as in Nos. 19, 21, 23, 28, 32, and 36.)

Weight.—(Without clothes) 126 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, November 22, 1895.

Table 26.—*Results of digestion experiment No. 17.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
101	Milk	2,310	255	67	81	107	15	1,557
102	Milk	2,495	279	77	92	110	16	1,766
103	Bread	979	703	97	16	590	10	3,098
	Total		1,237	241	189	807	41	6,421
104	Feces, water-free	32	22	6	4	12	9	170
	Amount digested		1,215	235	185	795	32	6,251
	Per cent digested		98.2	97.5	97.9	98.5	78.0	
	Estimated heat of combustion of urine							317
	Net energy of food oxidized							5,934
	Per cent energy utilized							92.4

The separation of the feces was clearer and more accurate in this experiment than in the previous one, but still left much to be desired.

DIGESTION EXPERIMENT No. 18.

Kind of food.—Bread and milk.

Subject.—Chemist, 26 years of age, with a moderate amount of exercise. (Same subject as in Nos. 16, 20, 22, 26, 31, and 34.)

Weight.—(Without clothes) 143 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, December 12, 1895.

TABLE 27.—*Results of digestion experiment No. 18.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
106	Milk	2,916	356	95	129	132	19	2,170
107	Milk	2,135	277	72	104	101	15	1,719
108	Bread	1,259	832	114	16	702	13	3,615
	Total		1,465	281	249	935	47	7,504
110	Feces, water-free	50	35	11	6	18	15	246
	Amount digested		1,430	270	243	917	32	7,258
	Per cent digested		97.6	95.7	97.6	98.1	68.1	
	Estimated heat of combustion of urine							365
	Net energy of food oxidized							6,893
	Per cent energy utilized							91.9

The line of demarcation of the feces was good. In these and the following experiments the urine was collected during the period covered by the digestion experiment, and the nitrogen therein determined. In this experiment the total urine for the two days weighed 2,382 grams and contained 1.84 per cent, or 43.8 grams, of nitrogen.

DIGESTION EXPERIMENT No. 19.

Kind of food.—Bread and milk.

Subject.—Chemist, 25 years of age, with almost no exercise. (Same subject as in Nos. 17, 21, 23, 28, 32, and 36.)

Weight.—(Without clothes) 127 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast. December 12, 1895.

TABLE 28.—*Results of digestion experiment No. 19.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
106	Milk	2,756	336	89	122	125	18	2,050
107	Milk	2,600	337	88	126	123	18	2,093
108	Bread	859	567	77	11	479	9	2,466
	Total		1,240	254	259	727	45	6,609
109	Feces, water-free	36	25	7	6	12	11	191
	Amount digested		1,215	247	253	715	34	6,418
	Per cent digested		98.0	97.2	97.7	98.3	75.6	
	Estimated heat of combustion of urine							333
	Net energy of food oxidized							6,085
	Per cent energy utilized							92.1

The separation of the feces was good. The weight of the urine for the two days was 2,506 grams, containing 0.93 per cent, or 23.4 grams, of nitrogen.

DIGESTION EXPERIMENT No. 20.

Kind of food.—Bread and beef.

Subject.—Chemist, 26 years of age, with moderate exercise. (Same subject as in Nos. 16, 18, 22, 26, 31, and 34.)

Weight.—(Without clothes) 142 pounds at the beginning and 140 at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 10, 1896.

TABLE 29.—*Results of digestion experiment No. 20.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
113	Beef	715	187	146	41		8	1,205
115	Beef	800	211	155	56		9	1,423
114	Bread	631	429	60	11	358	6	1,929
	Total		827	361	108	358	23	4,557
118	Feces, water-free	38	33	18	4	11	5	183
	Amount digested		794	343	104	347	18	4,374
	Per cent digested		96.0	95.0	96.3	96.9	78.3	
	Estimated heat of combustion of urine							463
	Net energy of food oxidized							3,911
	Per cent energy utilized							85.8

The beef was prepared as Hamburg steak; that is, chopped in a meat cutter before cooking; the bread was the same kind as in the previous experiments; the only beverage was water. The diet became so repulsive before the close of the second day that it could only be eaten with difficulty, and there was a feeling of hunger accompanied by headache.

In spite of this fact the amount of digested nutrients was large. There were 2,757 grams of urine for the two days, with 1.86 per cent, or 51 grams, of nitrogen.

DIGESTION EXPERIMENT No. 21.

Kind of food.—Bread and meat.

Subject.—Chemist, 25 years of age, with almost no exercise. (Same subject as in Nos. 17, 19, 23, 28, 32, and 36.)

Weight.—(Without clothes) 128 pounds at the beginning and 126 at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 10, 1896.

TABLE 30.—*Results of digestion experiment No. 21.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
113	Beef	315	82	64	18	....	3	531
115	Beef	350	93	68	25	....	4	623
114	Bread	401	273	39	7	227	4	1,226
	Total	....	448	171	50	227	11	2,380
117	Feces, water-free	25	22	12	4	6	3	138
	Amount digested	....	426	159	46	221	8	2,242
	Per cent digested	....	95.1	93.0	92.0	97.4	72.7	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	215
	Net energy of food oxidized	....	....	....	....	....	....	2,027
	Per cent energy utilized	....	....	....	....	....	....	85.2

The diet, which was the same as in No. 20, became very repulsive, and the subject lost 2 pounds in weight, although the food was well digested and was sufficient in amount. There were 25.1 grams of nitrogen in the urine for the two days, which was 2,884 grams in amount and contained 0.87 per cent nitrogen.

DIGESTION EXPERIMENT No. 22.

Kind of food.—Bread, milk, and eggs.

Subject.—Chemist, 26 years of age, with a moderate amount of exercise. (Same subject as in Nos. 16, 18, 20, 26, 31, and 34.)

Weight.—(Without clothes) 143 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, February 27, 1896.

TABLE 31.—*Results of digestion experiment No. 22.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
144	Eggs	984	230	130	100		10	1,694
140	Milk	1,866	240	61	83	96	13	1,439
141	Milk	2,016	241	65	75	101	14	1,482
142	Bread	729	491	74	10	407	8	2,148
	Total		1,202	330	268	604	45	6,763
146	Feces, water-free	64	47	19	14	14	17	306
	Amount digested		1,155	311	254	590	28	6,457
	Per cent digested		96.1	94.2	94.8	97.7	62.2	
	Estimated heat of combustion of urine							420
	Net energy of food oxidized							6,037
	Per cent energy utilized							89.3

The diet was the same as in experiments Nos. 16 to 19, with the addition of eggs. These were usually prepared by boiling, but were occasionally poached. There was no feeling of hunger, nor was the food repulsive. In this and the subsequent experiments the separation of the feces could be made with great accuracy. There were 42.5 grams of nitrogen (1.99 per cent) eliminated in the 2,185 grams of urine during the two days.

DIGESTION EXPERIMENT No. 23.

Kind of food.—Bread, milk, and eggs.

Subject.—Chemist, 25 years of age, with almost no exercise. (Same subject as in Nos. 17, 19, 21, 28, 32, and 36.)

Weight.—(Without clothes) 131 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, February 27, 1896.

TABLE 32.—*Results of digestion experiment No. 23.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
144	Eggs	780	182	103	79		8	1,343
140	Milk	1,854	238	60	83	95	13	1,429
141	Milk	1,939	232	63	72	97	14	1,425
142	Bread	539	363	55	7	301	6	1,588
	Total		1,015	281	241	493	41	5,785
148	Feces, water-free	61	45	14	15	16	16	342
	Amount digested		970	267	226	477	25	5,443
	Per cent digested		95.6	95.0	93.8	96.8	60.9	
	Estimated heat of combustion of urine							360
	Net energy of food oxidized							5,083
	Per cent energy utilized							87.9

As in the previous experiment, the diet was agreeable and everything normal throughout. The eggs were sometimes boiled and sometimes poached. The urine for the two days amounted to 2,782 grams, with 1.17 per cent, or 32.5 grams, of nitrogen.

DIGESTION EXPERIMENT No. 24.

Kind of food.—Bread, milk, and eggs.

Subject.—Student, 20 years of age, with a moderate amount of exercise.

Weight.—(Without clothes) 146.3 pounds at the beginning and 145 pounds at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, February 27, 1896.

TABLE 33.—*Results of digestion experiment No. 24.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
144	Eggs	1,034	241	136	105		10	1,780
140	Milk	1,926	248	63	86	99	14	1,485
141	Milk	2,387	285	78	88	119	17	1,754
142	Bread	559	376	56	8	312	6	1,647
	Total		1,150	333	287	530	47	6,666
147	Feces, water-free	72	57	22	12	23	15	388
	Amount digested		1,093	311	275	507	32	6,278
	Per cent digested		95.1	93.4	95.8	95.7	68.1	
	Estimated heat of combustion of urine							420
	Net energy of food, oxidized							5,858
	Per cent energy utilized							87.9

The subject in this experiment was different from either of those in the preceding studies, and perhaps had not become accustomed to a diet so limited in variety; at least the food became somewhat repulsive to him, and he lost 1.3 pounds in weight during its continuation. The weight of urine for the two days was 2,610 grams, containing 1.49 per cent, or 38.9 grams, nitrogen.

DIGESTION EXPERIMENT No. 25.

Kind of food.—Bread, milk, and eggs.

Subject.—Chemist, 26 years of age, with a small amount of active exercise. (Same subject as in No. 27.)

Weight.—(Without clothes) 134 pounds at the beginning and 132 at end of experiment.

Duration.—Two days with six meals, beginning with breakfast, February 27, 1896.

TABLE 34.—*Results of digestion experiment No. 25.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
144	Eggs	805	188	106	82	....	8	1,386
140	Milk	949	122	31	42	49	7	732
141	Milk	935	112	30	35	47	7	687
142	Bread	707	475	71	10	394	7	2,084
	Total	....	897	238	169	490	29	4,889
149	Feces, water-free	39	31	10	10	11	8	222
	Amount digested	....	866	228	159	479	21	4,667
	Per cent digested	....	96.6	95.8	94.1	97.8	72.4	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	308
	Net energy of food oxidized	....	....	....	....	....	....	4,359
	Per cent energy utilized	....	....	....	....	....	....	89.2

Although the food did not become repulsive in this case as in No. 24, the subject lost 2 pounds in weight during the two days. The total weight of urine was 1,470 grams, containing 1.71 per cent, or 25.1 grams, nitrogen.

DIGESTION EXPERIMENT No. 26.

Kind of food.—Mixed diet.

Subject.—Chemist, 26 years of age, with a moderate amount of exercise. (Same subject as in Nos. 16, 18, 20, 22, 31, and 34.)

Weight.—(Without clothes) 143 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, April 15, 1896.

TABLE 35.—*Results of digestion experiment No. 26.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
205	Corned beef (canned)	200	89	44	45	....	6	645
201	Milk	2,500	318	83	108	127	18	1,945
202	Milk	2,600	334	88	117	129	18	2,038
203	Oatmeal	240	219	46	19	154	41	1,010
204	Bread	475	323	48	5	270	5	1,380
	Sugar	100	100	....	....	100	....	410
206	Bananas	965	213	12	7	194	7	798
	Total	....	1,596	321	301	974	95	8,226
208	Feces, water-free	84	58	23	12	23	26	376
	Amount digested	....	1,538	298	289	951	69	7,850
	Per cent digested	....	96.4	92.8	96.0	97.6	72.6	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	433
	Net energy of food oxidized	....	....	....	....	....	....	7,417
	Per cent energy utilized	....	....	....	....	....	....	90.2

The diet in this case was quite varied and larger in amount, owing to the fact that during the spring time the subject was taking more exercise than in the fall and winter. The total urine for the period weighed 2,240 grams, and contained 1.65 per cent, or 37 grams, nitrogen.

DIGESTION EXPERIMENT No. 27.

Kind of food.—Mixed diet.

Subject.—Chemist, 26 years of age, with almost no exercise. (Same subject as in No. 25.)

Weight.—(Without clothes) 133 pounds at the beginning and 131.5 at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, April 15, 1896.

TABLE 36.—*Results of digestion experiment No. 27.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
205	Corned beef (canned)	211	93	46	47	....	7	680
201	Milk	476	60	16	20	24	3	370
202	Milk	800	103	27	36	40	6	627
203	Oatmeal	155	142	30	12	100	3	653
204	Bread	708	481	71	8	402	7	2.058
	Sugar	76	76	....	....	76	....	312
	Molasses	150	110	....	....	110	....	449
206	Bananas	89	20	1	1	18	1	74
	Total	....	1,085	191	124	770	27	5,223
210	Feces, water-free	45	38	15	9	14	7	242
	Amount digested	....	1,047	176	115	756	20	4.981
	Per cent digested	....	96.5	92.1	92.7	98.2	74.1	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	238
	Net energy of food oxidized	....	....	....	....	....	....	4,743
	Per cent energy utilized	....	....	....	....	....	....	90.8

The diet in this experiment was the same as in the preceding one, except the substitution of molasses for part of the sugar. Although the diet was varied the subject lost in weight during the study. The urine for the two days was 1,420 grams in amount and contained 1.70 per cent, or 24.1 grams, of nitrogen.

DIGESTION EXPERIMENT No. 28.

Kind of food.—Mixed diet.

Subject.—Chemist, 25 years of age, with a small amount of active exercise. (Same subject as in Nos. 17, 19, 21, 23, 32, and 36.)

Weight.—(Without clothes) 133 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, April 15, 1896.

TABLE 37.—*Results of digestion experiment No. 28.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
205	Corned beef (canned)	150	66	33	33	....	5	484
201	Milk	2,717	345	90	117	138	19	2,114
202	Milk	2,500	321	84	113	124	18	1,960
203	Oatmeal	130	119	25	10	84	2	547
204	Bread	262	178	26	3	149	3	761
	Molasses	250	183	....	....	183	....	749
206	Bananas	419	93	5	3	85	3	346
	Total	....	1,305	263	279	763	50	6,961
209	Feces, water-free	71	52	17	12	23	19	358
	Amount digested	....	1.253	246	267	740	31	6,603
	Per cent digested	....	96.0	93.5	95.7	97.0	62.0	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	332
	Net energy of food oxidized	....	....	....	....	....	....	6,271
	Per cent energy utilized	....	....	....	....	....	....	90.1

As in the previous experiment molasses was used to some extent in place of sugar, otherwise the diet was as in No. 26. The weight of the urine was 2,889 grams and its nitrogen content 0.77 per cent, or 22.2 grams.

DIGESTION EXPERIMENT No. 29.

Kind of food.—Bread, milk, oatmeal, and sugar.

Subject.—Student, 20 years of age. (Same subject as in No. 35.)

Weight.—(Without clothes) 136 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 14, 1897.

TABLE 38.—*Results of digestion experiment No. 29.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
242	Milk	2,100	251	75	64	112	16	1.630
243	Milk	2,100	274	71	101	102	15	1,800
245	Oatmeal	238	214	40	18	156	4	962
244	Bread	596	391	61	7	323	5	1.728
	Sugar	119	119	....	....	119	....	488
	Total	....	1,249	247	190	812	40	6,608
247	Feces, water-free	72	52	17	9	26	20	351
	Amount digested	....	1.197	230	181	786	20	6,257
	Per cent digested	....	95.8	93.1	95.3	96.8	50.0	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	311
	Net energy of food oxidized	....	....	....	....	....	....	5,946
	Per cent energy utilized	....	....	....	....	....	....	90.0

The bread used was the "Vienna" loaf; the milk was furnished by a private family. The oatmeal was one of the patent preparations of rolled oats. The subject was in good health during the experiment and relished his food. The amount of urine for the period was 3,189 grams, the percentage of nitrogen 0.91, making a total elimination of 29 grams of nitrogen during the experiment.

DIGESTION EXPERIMENT No. 30.

Kind of food.—Milk, bread, oatmeal, and sugar.

Subject.—Student, 21 years of age. (Same subject as in No. 33.)

Weight.—(Without clothes) 156 pounds at the beginning and 155½ at the end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 14, 1897.

TABLE 39.—*Results of digestion experiment No. 30.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
242	Milk	2,100	251	75	64	112	16	1,630
243	Milk	2,100	274	71	101	102	15	1,800
245	Oatmeal	307	276	52	23	201	5	1,241
244	Bread	705	462	72	9	381	6	2,044
	Sugar	112	112			112		459
	Total		1,375	270	197	908	42	7,174
248	Feces, water-free	81	64	24	19	21	17	422
	Amount digested		1,311	246	178	887	25	6,752
	Per cent digested		95.4	91.1	90.4	97.7	59.5	
	Estimated heat of combustion of urine							332
	Net energy of food oxidized							6,420
	Per cent energy utilized							89.5

The urine eliminated during the experiment amounted to 3,304 grams, containing 0.90 per cent or 29.7 grams of nitrogen.

DIGESTION EXPERIMENT No. 31.

Kind of food.—Milk, bread, wheatlet, and sugar.

Subject.—Chemist, 27 years of age, with a moderate amount of exercise. (Subject same as in Nos. 16, 18, 20, 22, 26, and 34.)

Weight.—(Without clothes) 142 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 14, 1897.

TABLE 40.—*Results of digestion experiment No. 31.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
242	Milk	2,219	265	79	68	118	17	1,722
243	Milk	2,160	282	73	104	105	16	1,851
246	Wheatlet	350	315	46	8	261	4	1,291
244	Bread	560	367	57	7	303	5	1,623
	Sugar	77	77			77		316
	Total		1,306	255	187	864	42	6,803
249	Feces, water-free	68	49	20	8	21	19	294
	Amount digested		1,257	235	179	843	23	6,509
	Per cent digested		96.3	92.2	95.7	97.6	54.8	
	Estimated heat of combustion of urine							317
	Net energy of food oxidized							6,192
	Per cent energy utilized							91.0

The food in this experiment was the same as in the two preceding, with the substitution of wheatlet for oatmeal. The amount of urine eliminated in the period was 4,224 grams, containing 0.95 per cent or 40.1 grams of nitrogen.

DIGESTION EXPERIMENT No. 32.

Kind of food.—Milk, bread, wheatlet, and sugar.

Subject.—Chemist, 26 years of age, with a small amount of active exercise. (Same subject as in Nos. 17, 19, 21, 23, 28, and 36.)

Weight.—(Without clothes) 126 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 14, 1897.

TABLE 41.—*Results of digestion experiment No. 32.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
242	Milk	2,232	267	79	69	119	17	1,732
243	Milk	2,100	274	71	101	102	15	1,800
246	Wheatlet	122	109	16	2	91	1	450
244	Bread	373	245	38	5	202	3	1,081
	Sugar	113	113			113		463
	Total		1,008	204	177	627	36	5,526
250	Feces, water-free	49	34	11	9	14	15	238
	Amount digested		974	193	168	613	21	5,288
	Per cent digested		96.6	94.6	94.9	97.8	58.3	
	Estimated heat of combustion of urine							261
	Net energy of food oxidized							5,027
	Per cent energy utilized							91.0

The subject took practically no exercise, but felt well and apparently lost no weight. The elimination of urine for the period was 3,898 grams, containing 25.3 grams (0.65 per cent) of nitrogen.

DIGESTION EXPERIMENT No. 33.

Kind of food.—Milk, bread, canned beef, canned corn.

Subject.—Student, 21 years of age. (Same subject as in No. 30.)

Weight.—(Without clothes) 154 pounds at the beginning and 155 at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 22, 1897.

TABLE 42.—*Results of digestion experiment No. 33.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams*	*Calories.*
258	Canned beef	423	165	115	50	....	19	1,066
252	Milk	2,350	337	81	120	136	16	2.028
253	Milk	2,350	310	70	119	121	16	1,882
254	Bread	606	387	59	8	320	8	1,739
257	Canned corn	1,520	347	42	17	288	8	1,537
	Total	....	1,546	367	314	865	67	8,252
260	Feces, water-free	146	120	43	32	45	26	730
	Amount digested	....	1,426	324	282	820	41	7,522
	Per cent digested	....	92.2	88.3	89.8	94.8	61.2	....
	Estimated heat of combustion of urine							437
	Net energy of food oxidized							7,085
	Per cent energy utilized							85.9

The subject ate heartily and felt well, but apparently lost some flesh during the experiment. The elimination of urine for the period was 3,799 grams, containing 1.27 per cent, or 48.2 grams of nitrogen.

DIGESTION EXPERIMENT No. 34.

Kind of food.—Milk, bread, canned corn, boiled ham.

Subject.—Chemist, 27 years of age, with a moderate amount of exercise. (Same subject as in Nos. 16, 18, 20, 22, 26, and 31.)

Weight.—(Without clothes) 140½ pounds at the beginning and 139½ at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 22, 1897.

TABLE 43.—*Results of digestion experiment No. 34.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
255	Boiled ham	250	75	55	20		16	469
252	Milk	2,417	347	83	124	140	17	2,086
253	Milk	2,340	309	69	119	121	15	1,874
254	Bread	764	488	74	10	404	10	2,193
257	Canned corn	850	194	23	10	161	4	859
	Total		1,413	304	283	826	62	7,481
261	Feces, water-free	84	61	23	11	27	23	345
	Amount digested		1,352	281	272	799	39	7,136
	Per cent digested		95.7	92.4	96.1	96.7	62.9	
	Estimated heat of combustion of urine							379
	Net energy of food oxidized							6,757
	Per cent energy utilized							90.3

The subject was not feeling as well as usual at the time of the experiment, which may account for his loss in weight. There was a total elimination of 3,459 grams of urine, containing 48.1 grams of nitrogen (1.39 per cent).

DIGESTION EXPERIMENT No. 35.

Kind of food.—Milk, bread, canned beef, potato chips.

Subject.—Student, 20 years of age. (Same subject as in No. 29.)

Weight.—(Without clothes) 136½ pounds at the beginning and 136 at end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 22, 1897.

TABLE 44.—*Results of digestion experiment No. 35.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
258	Canned beef	353	137	96	41		16	889
252	Milk	2,350	337	81	120	136	16	2,028
253	Milk	2,350	310	70	119	121	16	1,882
254	Bread	595	380	58	8	314	8	1,708
256	Saratoga chips	238	221	14	105	102	11	1,423
	Total		1,385	319	393	673	67	7,930
259	Feces, water-free	68	50	16	9	25	18	347
	Amount digested		1,335	303	384	648	49	7,583
	Per cent digested		96.4	95.0	97.7	96.3	73.1	
	Estimated heat of combustion of urine							409
	Net energy of food oxidized							7,174
	Per cent energy utilized							90.5

The bread used was so-called gluten bread, made from whole wheat flour; the beef, ordinary canned corned beef. The total elimination of urine for the period was 3,218 grams, containing 1.20 per cent, or 38.6 grams of nitrogen.

DIGESTION EXPERIMENT No. 36.

Kind of food.—Milk, bread, boiled ham, potato chips.

Subject.—Chemist, 26 years of age, with a small amount of active exercise. (Same subject as in Nos. 17, 19, 21, 23, 28, and 32.)

Weight.—(Without clothes) 126 pounds at the beginning and end of the experiment.

Duration.—Two days with six meals, beginning with breakfast, January 22, 1897.

TABLE 45.—*Results of digestion experiment No. 36.*

Lab. No. of sample.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.	Heats of combustion determined.
	Foods eaten:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
255	Boiled ham	227	68	50	18	....	15	426
252	Milk	2.300	330	79	118	133	16	1.985
253	Milk	2.350	310	70	119	121	16	1,882
254	Bread	409	262	40	6	216	5	1.174
256	Potato chips	181	168	11	80	77	8	1.083
	Total	....	1.138	250	341	547	60	6.550
262	Feces, water-free	73	52	15	21	16	21	361
	Amount digested	....	1,086	235	320	531	39	6,189
	Per cent digested	....	95.4	94.0	93.8	97.1	65.0	....
	Estimated heat of combustion of urine	....	....	....	....	....	....	317
	Net energy of food oxidized	....	....	....	....	....	....	5.872
	Per cent energy utilized	....	....	....	....	....	....	89.6

The total elimination of urine was 3,714 grams, containing 1.03 per cent, or 38.3 grams of nitrogen.

DISCUSSION OF THE RESULTS OF THE DIGESTION EXPERIMENTS.

If a person could subsist upon a single food material for any length of time it would be a comparatively easy matter to obtain the coefficients of digestibility of different materials. There are, however, very few food materials with which this is practicable. Even if the diet is limited for a time to one particular kind of food, as milk, bread, or meat, there is no assurance that the proportions of the different nutrients digested will be the same as would be the case were the food combined with other materials in an ordinary mixed diet. As an example of the difference between the digestibility of a single food material and of the same material when used in a mixed diet may be cited experiments with bread and milk. The average of ten experiments with an exclusively milk diet[1] showed 92.1 per cent of the protein and 86.3 per cent of the carbohydrates to be digested. Five experiments made with an exclusively bread diet or with bread and sugar[1] showed 82 per cent of the protein and 99 per cent of the carbohydrates to be digested. Five experiments with a diet of bread and milk[1] showed 97.1 per cent of the protein and 98.7 per cent of the carbohydrates to be digested. In other words, the protein in milk alone or in bread alone seems to be much less completely digested than when the two are eaten together. Whether the same would hold true of other food materials there is no certain means of knowing. But it would seem reasonable to suppose that more complete digestion would occur when the diet was nearly normal; that is, made up of a number of food materials.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 61; Connecticut Storrs Sta. Rpt. 1896, p. 163.

These statements are, of course, to be interpreted in the light of what was said on page 25 regarding metabolic products and the undigested residues of food in the intestinal excretion. That is to say, the percentages of nutrients which are taken as digested in these calculations represent the difference between the amounts in the food and the material excreted in the feces. It may be that part of the difference in the digestibility of the single-food materials as compared with those of the mixed diet may be due to differences in the amounts of metabolic products excreted.

The results of the above experiments are summarized in the following table, which shows the coefficients of digestibility of the different nutrients as found in the experiments:

TABLE 46.—*Summary of the 21 digestion experiments here reported, showing coefficients of digestibility found.*

Dig. expt. No.	Subject.	Kind of food and weights per day (in grams).	Total organic matter.	Protein.	Fat.	Carbohydrates.	Ash.	Available energy.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
16	A	Bread 663, milk 2,532	98.9	97.5	98.5	99.3	85.1	93.7
17	B	Bread 490, milk 2,402	98.2	97.5	97.9	98.5	78.0	92.4
18	A	Bread 630, milk 2,525	97.6	95.7	97.6	98.1	68.1	91.9
19	B	Bread 430, milk 2,678	98.0	97.2	97.7	98.3	75.6	92.1
		Average	98.2	97.0	97.9	98.6	76.7	92.3
20	A	Bread 315, beef 758	96.0	95.0	96.3	96.9	78.3	85.8
21	B	Bread 200, beef 333	95.1	93.0	92.0	97.4	72.7	85.2
		Average	95.6	94.0	94.2	97.2	75.5	85.5
22	A	Bread 365, milk 1,941, eggs 492	96.1	94.2	94.8	97.7	62.2	89.3
23	B	Bread 269, milk 1,897, eggs 390	95.6	95.0	93.8	96.8	60.9	87.9
24	C	Bread 279, milk 2,157, eggs 517	95.1	93.4	95.8	95.7	68.1	87.9
25	D	Bread 354, milk 942, eggs 402	96.6	95.8	94.1	97.8	72.4	89.2
		Average	95.9	94.6	94.6	97.0	65.9	88.6
26	A	Bread 238, milk 2,550, oatmeal 120, corned beef 100, bananas 482, sugar 50	96.4	92.8	96.0	97.6	72.6	90.2
27	D	Bread 354, milk 638, oatmeal 78, corned beef 106, bananas 44, sugar 38, molasses 75	96.5	92.1	92.7	98.2	74.1	90.8
28	B	Bread 131, milk 2,609, oatmeal 65, corned beef 75, bananas 209, molasses 125	96.0	93.5	95.7	97.0	62.0	90.1
29	E	Bread 298, milk 2,100, oatmeal 119, sugar 59	95.8	93.1	95.3	96.8	50.0	90.0
30	F	Bread 353, milk 2,100, oatmeal 153, sugar 56	95.4	91.1	90.4	97.7	59.5	89.5
31	A	Bread 280, milk 2,190, wheatlet 175, sugar 38	96.3	92.2	95.7	97.6	54.8	91.0
32	B	Bread 187, milk 2,166, wheatlet 61, sugar 56	96.6	94.6	94.9	97.8	58.3	91.0
33	F	Bread 303, milk 2,350, corned beef 211, canned corn 760	92.2	88.3	89.8	94.8	61.2	85.9
34	A	Bread 382, milk 2,378, boiled ham 125, canned corn 425	95.7	92.4	96.1	96.7	62.9	90.3
35	E	Bread 298, milk 2,350, corned beef 176, potato chips 119	96.4	95.0	97.7	96.3	73.1	90.5
36	B	Bread 205, milk 2,325, boiled ham 113, potato chips 90	95.4	94.0	93.8	97.1	65.0	89.6
		Average 11 with mixed diet	95.7	92.6	94.4	97.1	63.0	89.9

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[1] Digestion experiments Nos. 16–19, pp. 29–32, and Connecticut Storrs Sta. Rpt. 1896, p. 163.

The nitrogen balance.—The nitrogen of the digested protein is sooner or later eliminated from the body in the urea and allied compounds of the urine. The amount of nitrogen in the urine is usually taken as a measure of the amount of protein actually consumed within the body. If the quantity of nitrogen in the digested protein is the same during a given period as that eliminated in the urine the body is said to be in nitrogen equilibrium, i. e., it neither gains nor loses nitrogen. If there is a greater income of nitrogen in the digested food than outgo in the urine the body is storing nitrogen or protein, and vice versa if the nitrogen of the urine is in excess of that of the digested food the body is losing nitrogen or protein.

Under normal conditions the body remains in approximate nitrogen equilibrium. The fluctuations one way or the other will vary with the character and amount of the daily food and the muscular and other activity. In general the body will come into nitrogen equilibrium with any ordinary diet, provided the food is in sufficient quantity to furnish the necessary protein and energy. When the diet is changed so as to include a greater or a less quantity of nitrogen per day the balance of income and outgo will be disturbed and a certain time will be needed to establish the equilibrium with the new diet. The length of time will depend upon various conditions, including the kind and amount of food and the habits and peculiarities of the subject.

Some time is required for the metabolized nitrogen to be conveyed to the kidneys and excreted in the urine. The interval during which the excretion of nitrogen lags behind the metabolism may be termed the "nitrogen lag." For certain experiments of fundamental importance in the study of the laws of nutrition it is essential to obtain more information than is now available regarding the length of this period of nitrogen lag and the conditions upon which it depends. Attention is being given to this in connection with experiments now being carried on. This subject has been discussed and some of the experiments made have been noted in a previous publication.[1]

The urine was collected during nineteen of the digestion experiments previously reported and the nitrogen in it determined. With the aid of this additional data it was possible to determine the balance of nitrogen in the different experiments. This was done by subtracting (algebraically) the outgo in the urine and feces from the income in the food. From the gain and loss of nitrogen thus found the gain or loss of protein was calculated. The results are given in Table 47.

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 44.

TABLE 47.—*Daily nitrogen balance in the digestion experiments previously reported.*

No. of expt.	Daily diet, weights in grams.	Nitrogen. In food.	Nitrogen. In urine.	Nitrogen. In feces.	Nitrogen. Gain + or loss —.	Corresponding gain + or loss of protein.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*
18	Bread 630, milk 2,525	22.5	21.9	0.9	—0.3	— 1.9
19	Bread 430, milk 2,678	20.3	11.7	.6	+8.0	+50.0
20	Bread 315, beef 758	28.9	25.5	1.4	+2.0	+12.5
21	Bread 200, beef 333	13.7	12.6	1.0	+0.1	+ 0.6
22	Bread 365, milk 1,941, eggs 492	26.4	21.3	1.5	+3.6	+22.5
23	Bread 269, milk 1,897, eggs 390	22.5	16.3	1.1	+5.1	+32.5
24	Bread 279, milk 2,157, eggs 517	26.6	19.5	1.7	+5.4	+33.8
25	Bread 354, milk 942, eggs 402	19.0	12.6	.8	+5.6	+35.0
26	Bread 258, milk 2,550, oatmeal 120, corned beef 100, bananas 482, sugar 50	25.7	18.5	1.8	+5.4	+33.8
27	Bread 354, milk 638, oatmeal 75, corned beef 106, bananas 44, sugar 38, molasses 75	15.3	12.0	1.2	+2.1	+13.1
28	Bread 131, milk 2,609, oatmeal 65, corned beef 75, bananas 209, molasses 125	21.0	11.1	1.9	+8.0	+50.0
29	Bread 298, milk 2,100, oatmeal 119, sugar 59	19.8	14.5	1.4	+3.9	+24.4
30	Bread 353, milk 2,100, oatmeal 153, sugar 56	21.6	14.9	1.9	+4.8	+30.0
31	Bread 280, milk 2,190, wheatlet 175, sugar 56	20.4	20.1	1.6	—1.3	— 8.1
32	Bread 187, milk 2,166, wheatlet 61, sugar 56	16.3	12.6	.9	+2.8	+17.5
33	Bread 303, milk 2,350, corned beef 211, canned corn 760	29.4	24.1	3.4	+1.9	+11.9
34	Bread 382, milk 2,378, boiled ham 125, canned corn 425.	24.3	24.0	1.8	—1.5	— 9.4
35	Bread 298, milk 2,350, corned beef 176, potato chips 119	25.5	19.3	1.3	+4.9	+30.6
36	Bread 205, milk 2,325, boiled ham 113, potato chips 90.	20.0	19.2	1.2	—0.4	— 2.5

It is probable that the quantity of nitrogen in the urine here reported does not accurately represent the metabolized protein for the periods of the experiments for two reasons, (1) no allowance was made for the lag in the urine, and (2) the experiment was of too short duration. The figures simply show whether the subject was temporarily gaining or losing nitrogen. No record was kept of the food consumption immediately previous to the different experiments, but the nitrogen content of the food eaten during the experiments was, as a rule, quite high—higher, perhaps, than the subjects were accustomed to. This may account for the fact that there was, as a rule, a gain of nitrogen during the two days of the experiment.

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